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THE ENGINEERING MAGAZINE OF THE OIL AND GAS INDUSTRY

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Coming . .

Series on Elements of Applied Pipe-line and Transportation Practices

Many requests have been received from our readers in the pipe-line and transportation branch of the industry for a series of articles on the fundamentals of pipelining and the transportation of petroleum—a series similar to that now appearing on petroleum production and refining. Arrangements are now being made to comply with these requests and we hope to make a definite announcement within the next two months regarding it, at that time outlining the topics to be covered.

Meetings

Natural Gasoline Association of America—May 9, 10 and 11, Tulsa, Oklahoma.

•

International Petroleum Exposition—May 12 to 19, inclusive, Tulsa, Oklahoma.

•

American Society of Mechanical Engineers, National Petroleum Division—May 14, 15 and 16, Tulsa, Oklahoma.

•

American Petroleum Institute, Mid-Year Meeting — May 22, 23 and 24, Wm. Penn Hotel, Pittsburgh, Pennsylvania.

•

American Petroleum Institute, Fifteenth Annual Meeting — November 12, 13, 14 and 15, Dallas, Texas.

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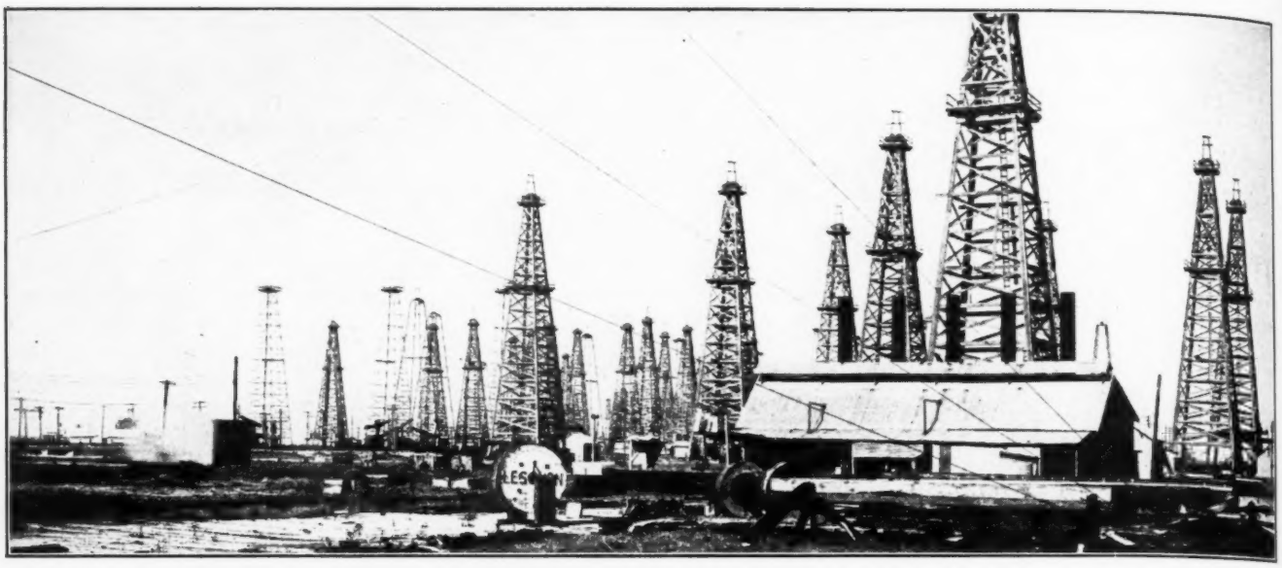

The Fallacy of Low *First* Cost

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The Course of Oil

By K. C. SCLATER

Orderly Development of New Fields

A vast improvement has been observed in all branches of the petroleum industry during the closing months of 1933. There is every indication that improvement will continue. The outlook for 1934 is particularly bright—much brighter than anyone dared hope a few months ago. The reasons for optimism are well founded.

A rapid readjustment to meet NRA code regulations has been taking place. Further readjustments of great moment are in prospect. On December 24 regulations covering the orderly development of new pools were announced by Mr. Ickes. While refusing to prohibit wildcatting, the Oil Administrator has no intention of allowing any more disorderly development to follow in the wake of the discovery of new pools. The free rein taken by producers in flush fields has been one of the most discouraging problems the industry has had to face in the past. There has been no medium at the disposal of the industry for giving effect to any sound policy concerning the development and production of new pools to the end that a sound market structure could be maintained. In announcing the regulations stipulating that plans to govern development of new pools must have his approval Mr. Ickes states:

"No plan will be approved by me which does not protect the correlative rights of all parties having an interest in the pool, nor will I approve any plan that does not permit full conservation of petroleum resources to prevent the waste of this irreplaceable fuel.

"Production from newly discovered fields will be restricted so as not to interfere unduly with the existing interstate market for petroleum and its products and drilling in new pools curbed to prevent unrestricted developments of excessive potentials.

"Provision is made for hearing of interested parties in any newly discovered area for which a plan of development is proposed. Likewise I may, in appropriate cases, submit any proposed plan to the Planning and Co-ordination Committee and/or other proper State Regulatory Agency for consideration.

"Under the regulations production shall not exceed the allowable quotas set by State Regulatory Bodies, or the Administrator, and shall at all times be without waste and limited to an output solely for beneficial use.

"The regulations also provide that I may take such steps as I consider necessary to achieve the desirable objective of orderly development, to conserve the supply of oil and gas which I consider absolutely necessary to the national welfare.

"Much of the confusion and chaos in the past few years in the oil industry can be directly traced to the wild outpouring of crude oil from newly discovered fields. This disorderly method of production demoralized markets by turning topsy-turvey the ordinary relationship between supply and demand, and in many instances drove crude prices down to give-away levels.

"Under plans for orderly development there should be no recurrence of such chaos and the regulations I am promulgating are designed to prevent a repetition of disastrous conditions."

Compliance with these regulations cannot but be of the most far-reaching benefit to all branches of the oil industry. In view of the proven value of natural underground storage, the piling up of stocks of oil above-ground in excess of immediate needs is a needless source of expense and loss; but more than that, it is a source of serious economic ills. The orderly development of new fields is a big stride toward better times and greater economic stability.

Water Encroachment Takes Its Toll

Water incursion in the Oklahoma City field is increasing and fluid levels are falling at a rate that is causing operators in that field no little concern. It is probable that within a few months many wells now flowing will have to be pumped or some other lifting method adopted to obtain production. In a field 6000 feet deep this is no ordinary problem. Producing wells successfully from this depth when a large quantity of water must be produced with the oil is seldom profitable, even when good prices obtain. The producing capacity of this field has reached its peak quicker than anticipated and its threat as a high potential capacity producer has passed.

In the Big Lake field, West Texas, water in some of the deep wells is also a matter of some concern. Now that the limits of this field have been almost completely defined it looks as if its potential capacity may not be quite so great as has been believed.

In the East Texas field, wells in increasing number continue to produce water in greater quantity. Only recently has it been suggested that wells making more than two per cent water be plugged back, a measure that if adopted would reduce the possibility of waterflooding in the sand and simplify the problem of water disposal. It is quite within reason that the Railroad Commission may see fit to promulgate an order to this effect. So even East Texas, the potential producing capacity of which for the last two years or more has been a constant threat to the oil industry, is already beginning to serve notice to the oil world that in order to produce the ultimate recovery estimated for it, the oil will have to be withdrawn at a conservative rate—whatever that may be—otherwise, water incursion may become a serious and a costly problem.

All this brings us face to face with the fact that though the demand for petroleum products continues to increase steadily, future sources of supply, even after discovery, may not be quite secure in meeting this increasing future demand. They are often subject to sudden change by vagaries of nature that, in our present state of knowledge, are beyond our ken. Water encroachment can be either a menace or a blessing, depending on how it is controlled.

« « « HIGHLIGHTS IN OILDOM » » »

Crude Stocks Lowered

There has been a marked improvement in the statistical position of the oil industry since the adoption of the NRA code. This is particularly true when crude oil stocks are considered. At the close of October, 1933, there were 356,885,000 bbl. of crude oil in storage in the United States. At the close of the week ending December 30, stocks of crude petroleum totaled 342,475,000 bbl., or a decline of 14½ million bbl. in two months' time.

This decline in crude oil stocks is due largely to the decreased production of oil in the United States, which at the end of 1933 was held to an average of 2,139,850 bbl. daily as compared with an output of 2,749,600 bbl. daily during the month of August, or prior to the NRA code. It is interesting to note that the daily average production of petroleum during the week ended December 30 was nearly 75,000 bbl. below the allowable fixed by the Federal agency.

•

Texas Allowable Upheld

Nine East Texas oil concerns have been enjoined from violating the State Railroad Commission's allowable production order by a Federal Court order. The judge stated that the injunctions would remain effective against violation of "further valid orders."

The decision of the three-judge court in the case, which attacks both the state allowable and certain provisions of the National Recovery Act under which the petroleum code was promulgated, has not as yet been handed down, but in view of the ruling in the above case oil leaders are more optimistic that the judges will uphold the regulations of the National Recovery Act.

•

Gasoline Taxes Reduced

Reduction of the Federal gasoline tax rate to one cent per gallon by elimination of the one-half-cent Federal tax on January 1, 1934, presages a savings to taxpayers of an estimated $75,000,000 in the new year and marks the first time in the history of gasoline taxation that a year has opened with a decrease in tax rates.

The Federal gasoline tax of one cent per gallon is scheduled to end June 30, 1934, unless re-enacted. The House Committee on Ways and Means already has been asked to end the tax on that date, and recommendations to that end have been made by the Senate Finance Committee. This would reduce the oil industry taxation by an additional $150,000,000 annually.

•

Texas Allowable Reduced

The allowable crude oil production for the State of Texas for the months of January, February and March has been set as 884,000 bbl. daily by the national oil administrator. The previous allowable was 888,000 bbl. per day. This allocation will remain in force throughout the first three months of 1934 unless material change in present conditions occur.

The Texas Railroad Commission, as it has in the past, fixed an allowable slightly beneath the figures permitted by the Federal agency. The Railroad Commission fixed the oil allowable at 881,996 bbl., of which amount East Texas was granted 399,187 bbl. daily.

•

Crude Oil Prices Advanced in Louisiana

The Louisiana Oil Refining Corporation, effective January 1, 1934, advanced the price for Urania field oil 12 cents per barrel to 87 cents. The H. L. Hunt, Inc., also announced a 10-cent advance in price for the same field, making its price 85 cents a barrel.

•

Fines Cancel Profits from "Hot Oil" Movement

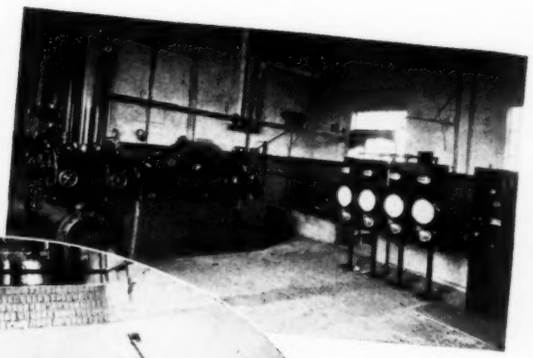
The Interior Department has made public details of six cases for violation of "hot oil" laws. Settlements in all the cases were made out of court as the result of charges of interstate movement of "hot oil." A total of $27,000 has been collected by State and Federal agencies as fines for the act of producing oil in excess of the allowable set for a particular area. The Texas operators who paid these fines admitted they had violated such laws.

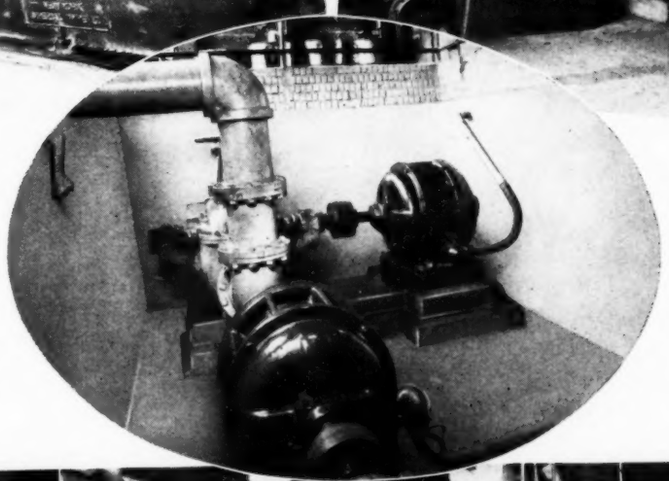
•

Another Alcohol Blending Bill Introduced

On January 3, Representative Gillespie of Illinois introduced a bill in the House of Representatives that provides for the use of alcohol as motor fuel. This bill is the same one introduced by this congressman last March, and which is still pending before the House Ways and Means Committee. Besides these two Gillespie bills, three other "alky-gas" bills, introduced at the special session last spring, are still alive. All provide for the use of 10 per cent alcohol by volume in motor fuels.

The Trend Is Toward *Purchased* Electric Power





(ABOVE, LEFT)—Ingersoll-Rand air compressor, V-belt driven by 100 hp. synchronous motor.

(ABOVE, RIGHT)—Direct connected air compressor driven by 125 hp. synchronous motor. Electric steam flow meters in the foreground.

(CENTER)—40 and 60 hp. induction motors direct connected to centrifugal water pumps.

(BELOW)—Battery of twenty Sharples centrifuges individually driven by 3 hp. induction motors.

Oil refineries, like other divisions of the petroleum industry, have found that purchased electric power is more economical when all factors are considered. . . . The above photographs were taken in the Fort Worth refinery of the Texas Pacific Coal and Oil Company.

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LATEST ACTIVITIES IN THE OIL FIELDS

ANOTHER new producing field was discovered in the Texas Coastal district when Gulf Production Company's Kirby Lumber Company 1, flowed 1300 bbl. of 41 gravity oil from 5724 feet. The new producer is located in Liberty County, near the town of Cleveland and is in the center of a 1214-acre lease. It is 15 miles east of the Conroe field, its production coming from the Cockfield sand. While Gulf apparently holds most of the producing acreage, the discovery is expected to add much impetus to wildcat drilling activity in the Gulf Coast.

●

Recent developments in the Long Lake area of Anderson County, Eastern Texas, have not improved its outlook. Thus far this district has failed to live up to the publicity it has been given as the most important discovery of 1933. One well has tested a strong flow of gas with some oil and an abundance of water, while another has cored into salt water. As a result of these disappointments, trading and leasing in the district has tapered off.

●

Another new pool has been added to the list of producing areas in Refugio County, in South Texas Gulf Coast. A well estimated as capable of producing 30 bbl. per hour from a depth of 3103 ft., has been completed along the northeast trend from Greta, Fox and Refugio fields.

●

The Greta field of Refugio County was extended one-half mile north by a test that flowed 30 bbl. per hour. The well is producing from the regular Greta sand at a total depth of 4400 feet. It is producing through a 3/16-in. choke.

●

The Louise district in Wharton County, Texas Gulf Coast region, is showing additional signs of becoming an important oil producer. A second producer has been completed in the field by the Pure Oil Company. This well is flowing 200 bbl. daily of 43.9 gravity oil.

●

The Tomball field in Harris County continues to be a puzzle to Texas Gulf Coast operators. Recent developments are as mixed as usual and have failed to improve the standing of the field. The producing area apparently underlies a large sector, but production will not be uniform.

●

North Kettleman Oil & Gas Company's Lillis-Welch 1, near the Kettleman Hills field in California, is redrilling below 10,300 ft. and making fair progress. If no trouble develops, drillers expect to reach the old bottom by February 1. It was the deepest hole in the world when the drill pipe was lost at 10,944 ft., at which depth it was showing oil and gas.

●

The western extension area of the Cut Bank field of Montana has been further proved by a well that appears to be good for 100 barrels. The lower Cut Bank sand was found between 2985-92 ft., where the well bailed 37 bbl. of oil in six hours, during which time the crude level in the hole was not lowered.

●

Gauges of Pure Oil Company Rhinehart 1, Ogemaw County, indicate that the well will make 2000 bbl. or better daily, which makes it the best completion in Michigan. When completed early in December it flowed 396 bbl. in three hours and then dropped off, subsequent deepening of the hole increasing its output to 152 bbl. an hour according to a recent one-hour open flow test.

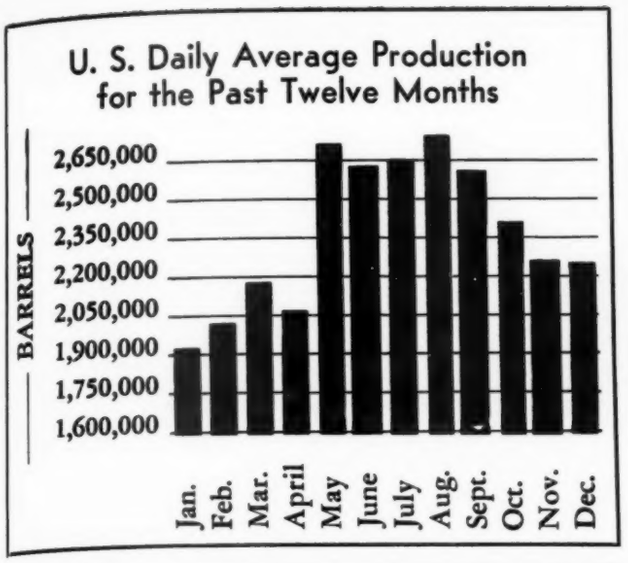
AVERAGE CRUDE OIL PRICES

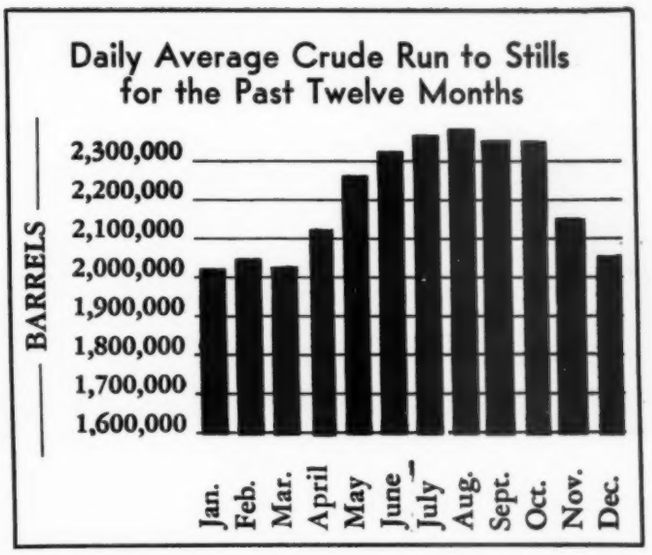
California		Arkansas	$ .70
Playa Del Rey	$ .90	Louisiana	
Coalinga	.81	North Louisiana	.95
Long Beach	1.00	Gulf Coast	1.04
Signal Hill	1.12		
Montana	1.35	Illinois	1.22
Wyoming	1.00	Kentucky	1.17
Colorado	1.00	Indiana	1.22
New Mexico	.75	Ohio	
Texas		Lima	1.30
North Central	.95	Wooster	1.15
Panhandle	.83	Michigan	1.02
West Texas	.70	Pennsylvania	
Gulf Coast	1.04	Bradford	2.45
Darst Creek	.87	Southwest	2.12
East Texas	1.00	Corning	1.20
Kansas	1.00	West Virginia	2.07
Oklahoma	1.00	Canada	2.10

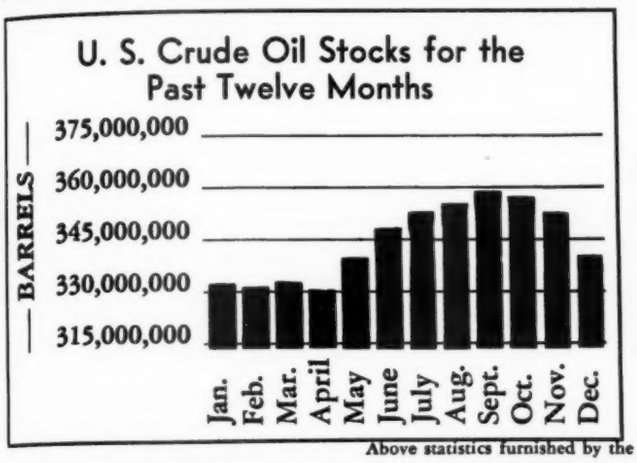
DAILY AVERAGE CRUDE OIL PRODUCTION

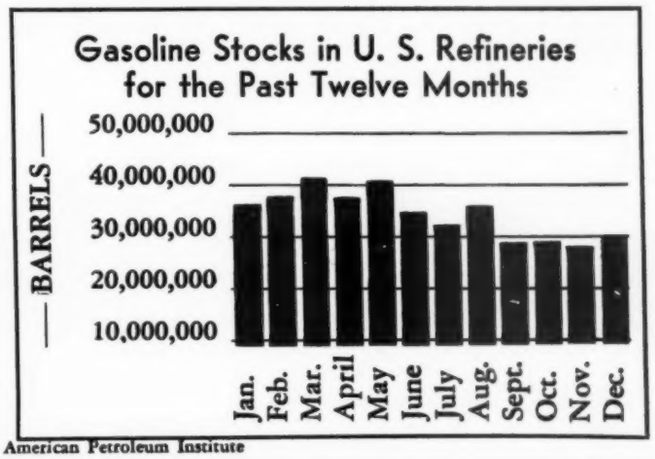
(Figures in Barrels)
Furnished by A.P.I.

	Federal Agency Allowable Effective Dec. 1	W'K Ended Dec. 30, 1933	W'K Ended Nov. 25, 1933	W'K Ended Dec. 31, 1932
Oklahoma	457,000	395,450	497,750	356,900
Kansas	112,000	109,850	116,300	89,850
Panhandle Texas		40,400	40,350	44,450
North Texas		57,450	57,300	47,300
West Central Texas		23,950	24,100	24,250
West Texas		119,600	121,700	156,550
East Central Texas		43,250	43,500	50,150
East Texas		406,800	394,250	
Conroe		55,800	55,650	23,100
Southwest Texas		40,600	43,300	52,200
Coastal Texas (Not incl. Conroe)		103,450	98,600	108,050
TOTAL TEXAS	888,000	891,000	878,750	506,050
North Louisiana		26,200	26,200	29,250
Coastal Louisiana		42,050	47,450	33,950
TOTAL LOUISIANA	69,000	68,250	73,650	63,200
Arkansas	33,000	32,300	33,300	32,800
Eastern (Not incl. Michigan)	94,200	89,500	95,150	92,950
Michigan	29,000	27,300	32,050	17,500
Wyoming	28,000	29,400	29,700	29,850
Montana	6,060	6,000	7,200	5,900
Colorado	2,240	2,400	2,450	2,700
TOTAL ROCKY MT. STATES	36,300	37,800	39,350	38,450
New Mexico	41,200	42,000	42,150	27,850
California	450,000	446,400	445,300	472,600
TOTAL U. S.	2,210,000	2,139,850	2,253,750	1,698,150









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for December, 1933

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas									
East Texas	329	324	307	66	289	3600	2	40	Rotary
Duval County	32	26	35	1	22	2300	2	22	Rotary
Conroe	33	30	30	11	30	5200	2	38	Rotary
Refugio County	30	29	16	7	21	3000–7400	3 or 4	40	Rotary
Oklahoma									
Oklahoma City	5	5	5	21	29	6500	3	39	Rotary
Kansas									
McPherson County	4	3	17	8	39	2900–4300	2	38	Rot-Cab.
Ellsworth Arch	6	5	24	17	38	3300	4	37	Cable
Harvey County	2	2	2	11	31	3450	2 or 4	37	Rot-Cab.
California									
Kettleman Hills	1	1	4	4	22	8300	3 or 4	40	Rotary
Long Beach	5	5	4	2	15	7000	3	26	Rotary

Field Actvities by States for December, 1933

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1932 (In Barrels)
	December	November	December	November	December	November	December	November	December	November	
Arkansas	4	0	4	0	3	5	7	15	38	29	11,907,000
California	39	27	34	26	36	34	35	46	140	159	178,128,000
Colorado	2	6	1	4	....	....	5	5	49	51	1,177,000
Illinois	1	0	0	0	....	....	2	1	11	13	4,661,000
Indiana	6	22	2	13	....	....	3	1	33	38	804,000
Kansas	49	68	37	56	69	48	21	25	136	125	34,300,000
Kentucky	24	19	13	7	....	....	1	2	54	53	6,264,000
Louisiana	50	43	34	21	42	64	79	72	170	130	21,478,000
Michigan	29	44	24	33	26	35	112	109	119	124	6,729,000
Mississippi	2	3	1	1	....	....	6	10	17	15	Gas Prod.
Montana	4	11	3	10	....	....	9	9	47	46	2,449,000
New Mexico	5	3	4	3	....	....	2	2	56	53	12,511,000
New York	18	0	17	0	....	....	3	1	14	16	3,501,000
Ohio	80	74	63	57	....	....	28	33	146	136	4,597,000
Oklahoma	130	126	92	79	156	150	102	95	369	302	151,621,000
Pennsylvania	191	205	117	150	....	....	20	21	88	98	12,403,000
Texas	734	711	579	576	704	630	209	257	959	887	311,069,000
West Virginia	14	31	11	28	....	....	23	23	69	53	4,472,000
Wyoming	3	7	3	3	....	....	6	5	69	67	12,359,000
Total	1385	1400	1039	1066	1036	966	673	732	2584	2395	781,845,000

PROGRESS OF MAJOR PIPE LINE WORK

By WARREN L. BAKER

FIGURES recently released by Alexander Forward, managing director of the American Gas Association, show that the natural gas industry was not as heavily "hit" during the depression as many others. As a result, considerable expansion in the natural gas industry can be forecast for the year 1934. Any enlargement programs naturally will necessitate the laying of additional pipe lines.

Sales of natural gas during the year 1933 amounted to 850,000,000 cu. ft., or an increase of two per cent over the preceding year. Revenues obtained from these sales totaled $305,000,000, a decline of three per cent. A particularly encouraging report comes from tabulation of natural gas sales for industrial purposes, which registered about seven per cent increase. However, domestic and commercial usage of natural gas declined approximately four per cent. Natural gas customers in 1933 were only 0.5 per cent fewer than in 1932.

●

Construction of a pipe line nearly 150 miles long to serve eight West Texas cities with natural gas is contemplated, according to an announcement by W. D. Howren, engineer, of Amarillo, Texas. Goldthwaite, San Saba, Lometa, Lampasas, Burnet, Llano, Fredericksburg and Kerrville, all Texas towns, would receive natural gas under the plans of John W. Moore & Sons of Lubbock, Texas, who are seeking a loan of $1,000,000 through the P.W.A. to construct an 8-in. line from the gas fields of Brown County to the aforementioned cities. An additional $400,000 loan is being sought by cities along the route for the purpose of building municipal distributing systems and plants.

●

The Regional P.W.A. Federal Emergency Board, with headquarters in Detroit, has under consideration an application to approve a loan of $485,000 to finance natural gas lines from the Mt. Pleasant, Mich., field south to the cities of Alma, St. Louis, Ithaca, St. Johns and other smaller communities. The application was given its first hearing December 15. The loan is sought by Leo S. Miller and James P. McCloskey, both of Detroit, and the Community Natural Gas Company of Mt. Pleasant. Miller & McCloskey have been granted franchises to distribute gas in all cities named, excepting Ithaca, where the franchise has not yet been put to a vote. The application is supported by officials and other residents of the towns to be served. The Michigan Federated Utilities Company, now servicing the cities with artificial gas, opposes the project. It is planned to obtain gas from wells in the Vernon and Clare County gas pools, which would require about 35 miles of pipe.

●

Stanolind Pipe Line Company continues its aggressive solicitation of well connections in Western Kansas. It is understood that the company has made arrangements with the Atlantic Oil Producing Company whereby Stanolind will construct a 4-in. line from Atlantic's wildcat well, near Seward, into the town, where a loading rack will be built on the Missouri Pacific railroad. This would require about 3½ miles of pipe.

Stanolind Pipe Line Company also is engaged in construction of 52 miles of 6-in. line from the Gorham area in Russell County to Holyrod in Rice County, where it will tie in with the company's present gathering system.

●

The new Louise field in Wharton County, Texas, Gulf Coast district, has been supplied with an outlet for the oil produced. The Pure Pipe Line Company has laid three miles of 4-in. line from the Pure Oil Company producers to a loading rack constructed on a nearby railway.

●

Salt City Gas Company is understood to be planning a gas line from gas production in northeastern Reno County, Kan., to Hutchinson, a distance of approximately 10 miles.

●

The Texas Railroad Commission has issued an order that defines the status of Channel Transport & Marketing Company as common carriers. The order requires them to comply with all provisions of the common carrier pipe line statutes within 20 days, which means they are required to file annual reports with the Commission and to charge uniform rates as fixed by the Commission.

This is the first case of its kind ever tried by the Commission and has established an important precedent. Both these companies move oil from the Conroe field. The companies had insisted they were not common carriers and had been handling oil at a lower transportation rate than that of 22½ cents fixed by the Commission.

THE MONTH'S ACTIVITIES IN REFINING

By F. R. STALEY

Per Cent Refining Capacity Operated

Eastern Division, 71.2 Per Cent **Central Division, 62.8 Per Cent** **Western Division, 52.1 Per Cent**

SECRETARY ICKES, as oil administrator, has approved a recommendation by the Petroleum Planning and Co-ordination Committee that provides for a curtailment of gasoline production. The resolution, in effect, places responsibility for allocating production to individual refiners on the regional subcommittees. It provides that each refining company shall conduct its operations so that it will comply with this order and contribute its full share to the attainment of an inventory level of 51,500,000 bbl. by January 31 and instructs the regional committees to take steps to carry out the order. Refiners whose production of gasoline exceeds the amounts designated by the agency acting for the regional committee shall notify their planning and co-ordination committee and submit reasons for their action, along with full statistical data.

●

A new 20,000 bbl. combination topping and cracking unit is being erected at the Philadelphia refinery of the Atlantic Refining Company. The unit, one of the largest distillation units ever designed, is being installed by the M. W. Kellogg Company. The equipment was specially designed so that crude oil will be topped of light gasoline, the naphtha cuts reformed and the gas oil cracked in one continuous operation. The products of the plant will be high octane gasoline and commercial grade fuel oil.

●

Construction of a modern cracking unit at the Henderson, Texas, refinery of the East Texas Refining Company will be started within a few weeks. Approved plans call for the installation of a new unit that will be used to convert the present 11,000 bbl. daily capacity topping plant into a 5000-bbl. capacity combination plant. The plant will be built under Donnelly patents, the East Texas company already having obtained a license from the Donnelly owners. This company operates a 10,000-bbl. capacity combination plant at Longview. The addition to the Henderson plant is expected to be completed within 75 to 90 days.

Considerable activity is taking place in Canadian refinery circles. H. Elliott plans a refinery at Peace River, Alberta. It will be designed to utilize heavy crude produced in the Wainright field and the principal product will be tractor fuel. Gold Standard Refining Company is rebuilding its Kling-Del refinery at Wainwright, Alberta. Canada's first high pressure natural gasoline plant has been placed on routine operating schedule, and is now processing 90,000,000 cu. ft. of Turner Valley gas daily. It is owned by the Royalite Company.

●

It appears that there will be a revival of construction activity in the natural gasoline industry during 1934. At the close of 1933 there were more plants under construction than at any time during the past two years. At this time three areas are the site of most of the gasoline plant work. These are the East Texas field, Texas Panhandle and Texas Gulf Coast area. A number of company officials, believing that the natural gasoline industry is about to stage a comeback, have laid out definite plans for expansion early in 1934.

●

Hanlon-Buchanan, Inc., has announced the completion of plans for the construction of a new natural gasoline plant east of Gladewater, in the East Texas field. Some 800 wells are being connected, which will provide a gas supply of 8,000,000 cu. ft. and a natural gasoline production of 25,000 gal. per day.

●

The Mohawk Petroleum Company has started construction work on a complete absorption and stabilizing unit near its new well in the Mountain View field of California. The design and construction is being done under contract by the Southwestern Engineering Corporation.

●

Otha H. Grimes of Tulsa, Okla., has started construction of a 5000-gal. natural gasoline plant in the Chippewa-Greendale field of Michigan. The plant will have a capacity of 2,500,000 cu. ft. per day, although as the field is developed its capacity will be enlarged.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending December 30, 1933

A.P.I. Figures

(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	478,000	82.1	15,023	7,120
Appalachian	92.6	89,000	63.7	2,095	1,058
Ind., Ill., Ky.	97.3	288,000	67.8	6,807	4,421
Okla., Kans., Mo.	82.1	201,000	53.0	5,474	3,744
Inland Texas	60.2	82,000	49.7	1,220	1,715
Texas Gulf	98.1	449,000	85.1	4,980	6,144
Louisiana Gulf	100.0	105,000	64.8	1,471	1,732
No. La.-Ark.	92.6	47,000	61.4	229	540
Rocky Mountain	78.8	32,000	50.3	874	706
California	96.9	443,000	53.9	13,585	92,021
TOTALS WEEK:					
December 23, 1933	92.4	2,214,000	66.2	51,758	119,201
December 16, 1933	92.4	2,191,000	65.5	50,802	120,054

Petroleum Production To Increasing Efficiency of

By LESTER C. UREN
Professor of Petroleum Engineering
University of California

RESEARCH, the key to industrial progress, is being supported in a substantial way by the Russian oil industry. Recent inspection of the petroleum research institutes at Moscow, Grozny and Baku and discussion with their respective staffs of the projects now under way and contemplated for the immediate future, leave the writer with the belief that more is being done in Russia within the field of petroleum production research than is being done in any other country. In these three institutes, more than a thousand workers are employed on projects relating to field exploitation, while a group equally large is concerned with oil refining problems. It is probable that no petroleum production research organization in America will compare in equipment, facilities and number of personnel employed with any one of these three Russian institutes.

THE AUTHOR

This seems more remarkable when it is recalled that Russia's petroleum production is less than a third that of the United States and that the Russian industry, generally speaking, is in a more primitive state of development than our own. The reason for Russian supremacy in this regard probably lies in the fact that theirs is a unified industry, while the American industry is comprised of a great many competitive units, mostly too small to justify support of large research programs. It is a matter of regret and, to some extent, a reflection on our organization ability, that some form of central coöperative research institute has not been organized in America to study the problems of the oil-producing industry.

It may be asked why, in Russia, there should be three separate petroleum research institutes, with inevitable overlapping and duplication of effort, instead of one large central research organization. The explanation lies in the desire to promote a healthy inter-institutional rivalry and to provide the opportunity of attacking research problems by separate personnel, developing their information and interpretations independently. Then, too, there are distinctly local problems to be studied, as at Grozny and Baku, while at Moscow the opportunity for collaboration and consultation with university and other technical institute staffs is helpful.

The emphasis placed on production research in the Russian oil industry will doubtless bring its reward in years to come in increased recovery efficiency and lower production costs. Though it is difficult to evaluate work of this character in terms of increased production and reduced initial cost, there is good reason for the belief that a thorough-going program of production research may double the future percentage recovery obtainable from petroleum deposits and halve the unit production cost. Such an achievement would justify an expenditure of money and labor many times that involved in the conduct of the necessary research. The results of research are applicable not only to the production of this year and next, but apply to all future time. Research is therefore a capital investment of the most permanent and enduring character and its value is not to be measured by its influence on current balance sheets. Costs and immediate profits are not the controlling factors in work of this character. Soviet economists seem to have a full appreciation of the place and value of research in the long-term planning in which they are engaged. Many of their foremost scientific men are participating in industrial research of this character. Being one of their key industries, the oil industry is receiving its full share in this development. Petroleum industry research in the Gini (Moscow), Grozny and Baku petroleum research institutes is conducted under the supervision of highly trained mature scientists. They have as their assistants groups of carefully selected workers who are for the most part recent graduates — both men and women — of Russian petroleum technology colleges or institutes. Each research project is a group effort in which several people qualified in different fields of science participate. Engineers, physicists, chemists, geologists, geophysicists, palaeontologists, metallurgists and economists bring their individual talents to bear as the development of each research project may require. The research staffs at Baku and Grozny work in close collaboration with the oil field administrative and technical personnel and much of their work is done in the field. The value of the research institutes as a training ground for further development of graduates of the technical colleges is also fully appreciated and close liaison is maintained with the faculties of the technical schools.

The petroleum research institute laboratories are well housed in modern buildings of permanent type and splendidly equipped with the best of scientific appliances. While some

Technology Research of Soviet Oil Industry

of the scientific apparatus is Russian made, much of it has been purchased abroad, particularly in Germany, France, England and the United States. Each research institute has its own instrument shops in which special equipment is constructed as projects under way may require.

Geological Research

Many research projects relate to petroleum exploration, to correlation of geologic horizons and to determination of properties and fluid content of formation encountered in drilling: matters in which geophysics, geo-chemistry, palaeontology and lithology find application. Important geological research is under way in both the Gini and Baku institutes.

Geophysics is playing an increasingly important rôle in the search for new oil deposits in Russia as elsewhere, and a group of technologists in the Gini institute is assigned the task of developing, testing and perfecting geophysical apparatus. They have recently been perfecting a new type of electrically operated, vibrating-diaphragm seismograph. The Schlumberger method of electrical coring has probably been more widely used in the Russian oil fields than anywhere else, and instruments for the many field parties engaged in this work are assembled and tested in the Gini laboratories. An outgrowth of this work has been the development of apparatus using the same resistivity principles for making surveys of wells to determine direction and amount of deflection from the vertical. Electrical resistivity apparatus has also been developed for general geophysical reconnaissance and is finding widespread use. An interesting application of such methods has been found in the mapping of structures several kilometers off-shore in the Caspian Sea, in the vicinity of Baku.

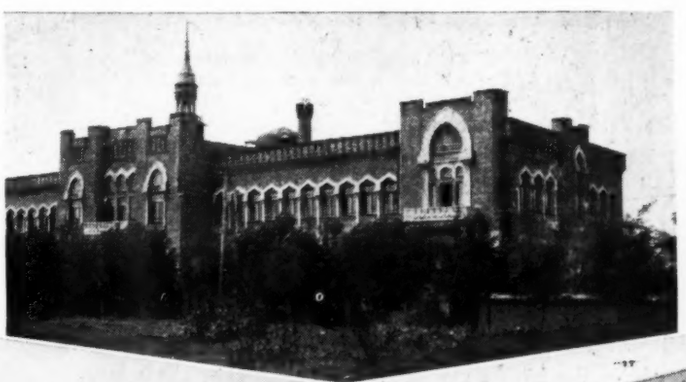
Extended study has been given in both the Gini and Baku laboratories to the identification of properties of oil reservoir and associated rocks. Personnel and equipment are available in both of these laboratories for mechanical analysis of sands and for determination of their porosity and permeability. Novel methods for determining the particle-size-distribution and chemical and physical constitution of clays have been developed. A large and expensive Roentgen ray apparatus has recently been installed in the Gini institute to assist in the clay investigations.

Classification and identification of micro-fauna have reached a high degree of perfection in Russian laboratories and work under way in both the Gini and Baku laboratories is contributing in an important way to the growing usefulness of this method or correlation. Excellent petrographic facilities are also available for mineral grain identification, the results of which work are found to be useful in certain areas as a means of correlation of stratigraphic horizons.

Laboratories equipped for chemical analysis of rocks, ground waters, oils and gases are available as service establishments and are in a position to make prompt inspections of materials submitted by exploration parties and oil-field operating organizations.

Drilling Problems

With newly discovered fields and many prospective areas



Right — One of the buildings occupied by the Grozny Research Institute, U.S.S.R.

Below—A portion of the group of buildings occupied by the Gini Petroleum Research Institute, Moscow, U.S.S.R.

Below—The Baku Petroleum Institute, where 1200 students are receiving technical preparation for U.S.S.R. oil industry occupations.

awaiting testing and development, much attention is being given to the improvement of drilling equipment and methods. Some of this work is necessarily being done in the field, but many problems are being investigated in the research laboratories.

Miniature rotary-drilling equipment built to approximate scale is being successfully used in a study of drill-pipe stresses, the mechanics of rotary drilling and the causes of crooked holes. A particularly ambitious program directed toward these ends is being conducted in the Grozny institute where a special steel tower and other essential equipment has been assembled. (See Fig. 1.) The drilling equipment is placed at the summit of the tower, while the drilling bit works in specially prepared sand- and cement-filled boxes in the building below. The miniature drill pipe (about ⅜ in. diameter) is maintained in a vertical position by supporting stays at various points and is available for inspection while at work throughout most of its length.

Fig. 1—Tower and building housing miniature drilling equipment, Grozny Research Institute

Studies have been made of the design of fish-tail bits to secure maximum footage and serviceability in field use. The various hard-facing alloys and their use on drilling bits have been carefully investigated.

The properties of rotary drilling fluids are being studied in the hope of finding means of successfully dealing with heaving sands and high formation pressures encountered in drilling in several of the Russian fields. Weighting materials and the preparation of high-density drilling fluids are of particular interest in this field of research. With the use of finely ground siderite ($FeCO_3$), stable drilling fluids having a density nearly twice that of water have been successfully prepared. An improved design for settling ditches for separating sand from drilling fluids has been a result of early work in this field. The extent to which drilling fluids penetrate sands and seal the pores of wall rocks of wells has been investigated and methods of promoting or controlling these tendencies have been developed. The characteristics of flow of mud fluids through pipes have also been a matter of interest, and formulæ expressing the relationship of the different variables involved have been developed.

Russian engineers have felt a proprietary interest in the turbo-drill, which from the start has been a product of Russian ingenuity and development. Improved designs have recently been prepared and extensive laboratory and field tests have been made under the direct supervision of the inventor, M. Kapelushnikov. So successful have these tests been that a large manufacturing establishment for quantity production of turbo drills has been built in one of the oil fields near Baku and a shop for their servicing and repair has recently been completed in the new Grozny field. Many details of mechanical design and development of wear-resisting materials have received careful attention in the perfection of this new and radically different type of drill, which apparently possesses definite advantages in power economy, freedom from accidents and in straight-hole drilling.

Among the many other practical operating details that have been receiving the attention of research workers, is a thorough-going investigation of the several different methods of bit-pressure control. A new design based on the use of a weight indicator in conjunction with other elements, providing positive control of the rotation of the drawworks in response to variations in bit pressure, has been worked out. A study has been made of the temperatures developed in drawworks brake-bands and of methods of avoiding over-heating in heavy service. Electrical power is almost exclusively used in the Russian fields and detailed studies of the power characteristics of drilling motors are being made.

Production Research

Difficult producing conditions characterize the more prolific Russian oil fields and the petroleum research institutes are attacking many of the problems of pumping and drainage, both in the laboratory and in the field. Both the ultra-practical and fundamental aspects of the drainage problem are being studied.

At both Grozny and Baku, laboratory apparatus is being constructed for study of the factors controlling radial drainage of oil through sand to a well outlet. Apparatus patterned closely after the conical drainage apparatus developed at the University of California under the direction of the writer, will be used for this purpose. Data to be gathered will be useful in estimating the drainage influence and pressure gradients about producing wells.

Much work has been done in analyzing the factors controlling operation of gas-lifts. Experimental gas-lifts have been used in the Gini and Baku institute laboratories and many studies have been made at operating installations in the field. An experimental well in the Baku district has been set aside for studies of this character. Novel methods of stage-lifting are being tested. Investigations are also being made of the efficiency of operation of oil-well plunger pumps of different types, and of methods of counterbalancing wells to reduce power consumption. Experimental pumping columns are being used in these investigations, as well as field installations. An extended study is being made of the causes of and possible remedies for corrosion of well equipment in gas-lift

Fig. 2—Portal of the experimental mine, Old Grozny Field, U.S.S.R.

and pumping operations. Promising results have been obtained through the use of chromium-plated pump valves and seats, in reducing normal wear and corrosion.

In many of the Russian fields, sand incursion creates difficult problems. Present production practice favors admitting a certain amount of sand to the wells with the oil, with the purpose of developing drainage cavities about the wells, but wear on pump parts and well equipment due to sand scouring and interruption of production due to frequent necessity for pump repairs and clean-out operations, are important disadvantages. Investigations have recently been made of the alternative advantages and disadvantages of screen pipe as a means of restraining sand influx, and experimental studies have been made, designed to assist in the selection of types of screens and sizes and shapes of screen openings for different sand conditions.

Development has progressed and production has declined in certain parts of the Grozny field to a point where it is considered timely to introduce "secondary" methods of recovery. Production from certain horizons and parts of the productive area is being stimulated by application of the Marietta or gas-driving process. Many details surrounding the application of this process have received the attention of the field engineering and research personnel. Possible application of water flooding as a means of increasing ultimate recovery in the Grozny area, is also being studied.

Plans have also been prepared for a large oil-mining project in the old Grozny field. Core drilling of one of the shallow zones in this field has disclosed a substantial reserve of oil left unrecovered by earlier exploitation and conditions seem otherwise favorable for application of a method of exploitation similar to that used in the Pechelbronn field in Alsace. An experimental mine in which some of the problems of oil mining are being investigated in a preliminary way, has already been initiated. (See Fig. 2). A tunnel has been driven to intersect the oil sand at some distance below an outcrop and drainage faces within the oil sand have been exposed. This experimental mine is proving useful in other sub-surface studies, particularly in investigating the extent to which mud fluid and cement forced into wells under pressure, penetrate sand interstices and crevices in the wall rocks. Operations are conducted from the surface in the usual way, through shallow wells drilled for the purpose, and later the wells are intersected by the mine workings for direct observation of results. The effects of explosives in forming shot cavities about wells, are also to be observed in this underground laboratory. The experimental mine is regarded as a phase of the activities of the Grozny research institute.

An especially ambitious project, involving installation of large-scale pipe-lines, pumps, tankage and control facilities, has been installed at the Gini institute in Moscow, to facilitate a comprehensive program of study of the flow of crude petroleum and refined petroleum products through pipe lines.

Testing Materials

In addition to the conduct of specific research projects, the Russian petroleum research institutes are charged with the responsibility of testing oil industry equipment and materials. Especially elaborate and costly equipment has been installed for this purpose, particularly in the Gini and Baku laboratories. The Baku institute has a well equipped metallographic laboratory and a powerful Roentgen ray apparatus for the detection of flaws in castings. Very complete and large-scale equipment for testing the strength of materials under tension, compression, torsion, and impact is available. Special appartus has been devised for studying the strength of heated specimens and for studying the "creep" of heated metals when under stress. Special machines have been constructed for studying fatigue failures of sucker rods and wire rope.

Research Publications

The Soviet petroleum research institutes are releasing the results of much of their investigative work through their official publications, particularly special research bulletins, monographs and professional papers in their oil-industry technical journals. The monthly journal "Azerbaidjan Petroleum Indutsry" has, during recent months, carried many papers written by technologists in immediate charge of research projects. Oil industry students will recall some very valuable contributions to petroleum technology that have recently come from these sources. Our American oil journals could perform a useful service by preparing and publishing translations of the best of these publications as they appear.

M.S.A. Combustion Gas Indicator

Gas Leakage S

NATURAL gas has been a public servant for many years in cities of various sizes in all parts of the United States. Many of these distribution systems were constructed 25 years and more ago, when pipe was laid unprotected. Today, after many years of faithful and excellent service, a number of the older city plants have begun to show unmistakable signs of weakening. This unseen picture is brought to mind when the monthly report shows that the percentage of "unaccounted-for" gas is steadily rising. The question arises, then, as to what is allowable leakage. From an economic viewpoint, any leakage the value of which is probably too small to be reduced by repairs would be allowable. This definition could likely be accepted if conservation and safety were not to be considered. The reduction of the loss of such a valuable natural resource as natural gas is, as should be, of vital importance to gas users. Considering the amount of gas now available, it would seem that the loss of a few thousand feet would not be serious, but if, by chance, it accumulated in the walls of some structure, presenting a fire hazard, any combustible volume would be too much.

Even though the plant operator should prefer the ideal plant with no leakage, he will, in all probability have one of three general types. The first type approaches the ideal. There may be occasional leakage if a line is pulled apart either by ground action or damage in construction work. The second type presents localized trouble. In some areas where trouble with electrolysis or corrosion is encountered perodic repairs or replacements are necessary. The third type is chronic, and the operator is continually making repairs, trying to get the most from what lines are already in the ground. It would seem unprofitable to rebuild the plant, so it becomes a matter of trying to keep the "unaccounted-for" percentage as low as possible. Problems are individual in such systems and the operator's knowledge of this fact determines, to a large extent, how they should be met.

Believing that a better and safer service would result if some leakage survey was made, the management of our company stipulated that many of the small plants be odorized with Cal-odorant No. 3. To do this work, the company ordered six pressure tanks similar to the one shown and costing $11.00 each. These tanks were made from light-gauge steel and tested with 100 lb. water pressure. When delivered to our machine shop, ½-in. collars were welded on and taps made at all connection points. They were then subjected to 75-lb. air pressure and soap tested for weld leaks, after which they were painted.

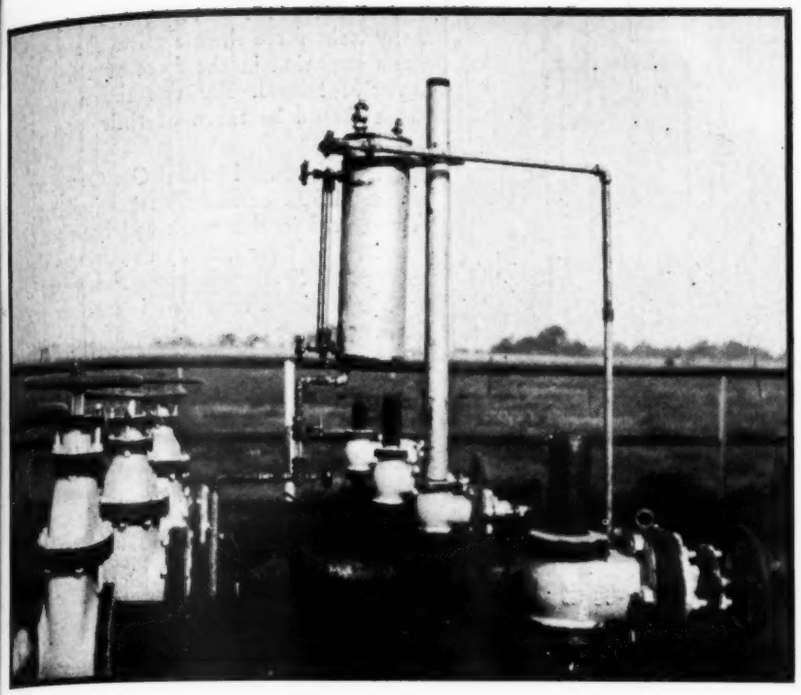
The general warehouse stocked several types of engine lubricators for use as sight feeds in the installation. These can be returned when the odorization work has been finished and used for their original purpose. The small internal top pressure line in these lubricators must be removed and the top plugged, otherwise the valve control sight feed would be by-passed. Any type sight feed oil lubricator can be used.

The tank, saddles, standards, a drum of Cal-odorant, lubricator, and all necessary fittings were then taken to the border station of the town selected as the first to be odorized in that district. The work of installing the unit is a relatively simple job, requiring the services of two men for about two hours, provided there is a tap available. All connections should be made up tight, using shellac on all threads. The liquid penetrates readily and unless care is taken in making the connections, leakage will occur.

The top pressure regulator line, with the stricture nipple removed, can often be used as the place of injection. Pressure regulation can be maintained with the gate valves during the short time this regulator is out of service.

The machine shop made a cap similar to the large one in the Cal-odorant drum, through which a ½-in. pipe was placed, the length being slightly shorter than the depth of the drum. Before the equalizer line is connected, a rubber hose can be hooked up from this tie to the ¾-in. tap in the drum and another from the larger tap to the top of the odorizing tank. Line pressure on the drum will then force the liquid Cal-odorant into the tank. The liquid level gauge glass will show when the estimated amount for that particular town has been forced into the tank. If the town is of such size that the entire drum, 55 gallons, is to be used, then a tank 42 in. long and 20 in. in diameter will be the correct size.

After the odorizing unit has been set up in the city border station, a date can then be decided upon to start the survey. Plumbers should be notified so that they can make preparation to take care of the several calls they will probably receive. Hand-bills are then distributed explaining the work to be done. A notice should also be published in the local paper. The following notice was used by our company:



An odorizer installation

Survey » »

By
ROY W. PARKER
Chemical Engineer
Oklahoma Natural
Gas Corporation

ATTENTION
GAS CUSTOMERS

To locate gas leaks and improve the efficiency of your service, beginning (Date), the Oklahoma Natural Gas Company will put a substance called "Cal-Odorant" into the gas lines of (Name of Town).

Cal-odorant is entirely harmless, but gives off an odor more pronounced than natural gas. If you find a leak in your home or on your premises, for the protection and safety of your family, you should immediately call a plumber. If you find a leak in the streets or alleys we will appreciate it if you will call our Service Department, (Phone number).

Your co-operation will be greatly appreciated and will save money for both you and the company.

Thank You

OKLAHOMA NATURAL GAS COMPANY

.....*District Manager.*

Unlike odorizing a city of several thousand services, no exact control of the amount of odorant injected is necessary. However, this could be done by regulating the number of drops per minute into a constant load, such as a small town requires. We began with a low concentration in the first couple of towns, but soon realized that we were not locating the leaks we were so positive existed. With this low concentration, the plumbers had several calls to service leaking unions, stop-cocks, etc. No leaks of any consequence were located until the gas was super-saturated and remained so long enough to penetrate the soil over the lines.

With the low summer load in the towns of 250 to 1000 meters, a few gallons is sufficient to reach the maximum odorant volatility for the existing temperature and pressure. After the gas has been loaded with Cal-odorant two to four men can then make a complete inspection of the entire distribution plant. A general idea of where leakage is possibly occurring will prove valuable and help in planning the inspection schedule.

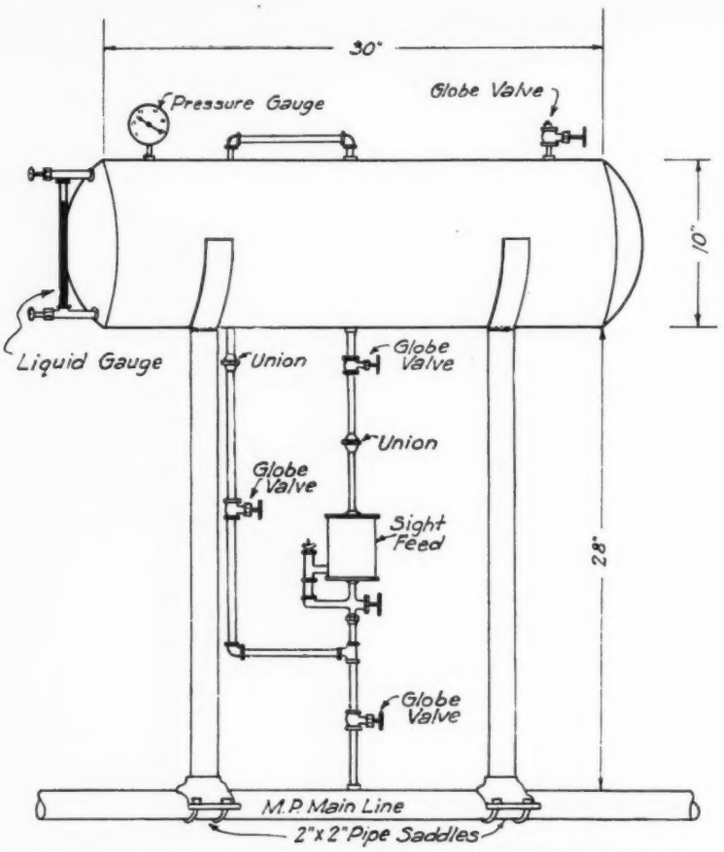
The distribution of the leakage is not always known but with a known percentage of "unaccounted-for" gas as the objective, you can be reasonably certain that if the minor complaints do not approach this percentage the loss is in the main distribution lines. In one of our towns there were only four or five small leaks reported, but two days later a 2-in. intermediate line was found broken at a tee. When repaired, the night load, which is indicative of the loss, dropped 80 per cent. In another town of equal size the following classification of leaks was reported: Appliances, 41; house-piping, 21; meters and regulators, 101; service lines, 7; main lines, 9. It is apparent, then, that unless some positive knowledge of the condition of the city plant is known we will have to make a very thorough survey of the entire system. The present city plant operator is often handicapped by the lack of correct prints or information passed on to him by prior superintendents. Formerly the more detailed records now kept were not thought necessary. In other towns odorized, it was reported that corncobs had been used to plug the ends of dead end lines. Abandoned lines were located. These were allowed to remain in the hope that someone would eventually tie on. One consumer failed to foresee any such leakage inspection resulting in the discovery of a leaky meter by-pass he had so carefully made.

The reports from the several towns odorized compare with each other very closely, except the one town where an extraordinarily large leak was located.

The percentage of decrease in volume passing the city border stations after odorization varied from 14 to 62 per cent. Other conditions remaining the same, this can be taken as the "unaccounted-for." One town dropped from 222 to 153 M.C.F., a reduction of 31 per cent; another from 150 to 85 M.C.F., a 43 per cent decrease; another, from 55 to 21 M.C.F., a 61 per cent decrease. Several graduated downward to 15 per cent, the minimum. A few leaks repaired after odorization had begun were known to exist, but the stench made locating them easier and less expensive.

We have no figures to show the exact saving that can be assigned to any particular district odorized. In fact, to place a monetary value on the saving would represent only an estimate. We know the cost and volume of the gas loss each month, but the damage it could do is problematical as is the ever-increasing loss from each point of failure due to stress and rate of pipe deterioration. A reasonable estimate of all this equipment and labor costs can be made. The equipment is portable and can be used in several locations each year for several years, therefore, the initial cost, when assigned to the several towns over a period of years, is small. All materials used, with the possible exception of the tank, is returnable to stock.

It is interesting to report that, in a few cases, the customers were somewhat annoyed by the use of this odorant, but when our service men explained that it was a temporary condition, to their advantage and for their safety, they



Gas odorizer designed by the author and used by Oklahoma Natural Gas Corporation

seemed to appreciate our efforts. They were unaware that the gas was odorized unless there were leaks about the house and naturally were glad to have these repaired. Consumers coöperated with us in each town and called the local plumbers, as suggested on the hand-bills. One local paper commended the company on the fine job it had done. Children playing about the town volunteered their services in finding leaks. They reported several, but in a few cases it was apparent that their enthusiasm influenced their sense of smell as the odor wasn't that of Cal-odorant.

I am informed by C. B. Day of the Consolidated Gas Service Company that his company has been doing some odorizing. The portable odorizer is installed on the main line at different points from time to time. This enables the locating of main line leaks as well as city plant leaks. After inspecting the odorant for a couple of days at any one place, the unit is placed in a specially constructed box, together with the miscellaneous fittings, and taken to another setting. An accompanying illustration shows in detail the unit and hook up (Page 21).

The above discussion gives in some detail the leakage work that has been done in our smaller city plants this summer. At some future date this leakage campaign may be conducted in the large cities of our system, but this does not mean that no account is taken of leakage in these cities at present.

General economic conditions the past few years have hindered plant operations pertaining to renewals and maintenance. Because of that fact, most operators have been forced to apply the limited amount of material and labor to those locations where it was most needed. To odorize and repair all leaks in a large city plant, particularly if the percentage of loss was reasonably high, would be a major undertaking. Many leaks of no consequence would have to be repaired and, considering their probable location under paving, it does not seem advisable. However, many leaks force themselves to the operator's attention in the form of a fire or explosive hazard. For this reason some check should be taken of their location and nature.

The Oklahoma Natural Gas Company has an M.S.A. combustible gas indicator that is used in this work and has found it satisfactory for quickly and accurately testing for flammable gases and vapors. An illustration shows this instrument. When we lay before us maps of the telephone, gas, water, sewer, and light companies' systems, we see a network of conduits, large lines, small lines, underground vaults, manholes, etc. They are running in all directions at different depths and each has its individual path. The transportation medium for any particular type of service usually is accessible at given places where vaults and manholes are provided. These lines furnish a line of least resistance for any escaping gas and, when it has accumulated in a manhole, an ideal explosion chamber is present. These areas should be inspected periodically to insure safety. Since the low explosive limit for natural gas is 4.8 per cent, it can readily be seen that a small volume is all that is necessary to form a potential bomb.

The company realizes this fact and makes manhole inspections with the combustible gas indicator. A brief description of the principles of operation follows: The sample is drawn in through a flexible hose by means of the aspirator bulb. It passes through a flash-back arrester, a flow orifice, thence to the combustion chamber where it is burned on the surface of the heated platinum wire filament. The heat is provided by two 6-volt batteries installed in the instrument. The combustion of the gas causes a rise in temperature and brings about a change in the electrical resistance of the filament in proportion to the amount of gas present. This is indicated by a milliammeter, calibrated to give a direct reading in percentage of explosives. The standard assembly may be calibrated for all usable gases.

We have found that two men, one to operate the instrument and the other to collect the data, can inspect approximately 125 manholes per day. When the survey has been completed you have a picture of the probable location of the leaks that cause this condition. A short time after the leaks are repaired, tests should be made if the operator would be positive that none has been missed. Varying percentages of combustibles from 0 to 100 in any direction give a very accurate location of the faulty section.

The gas indicator is used on all leakage complaints. Very often what is believed to be natural gas is escaping flue gases or foul air from the damp underground, but after the person complaining has observed the negative tests he is willing to accept your results.

In conclusion, it can be said truthfully that, even though plant reports show no gas "unaccounted-for," there undoubtedly exist a few leaks in city plants that have been in service for many years. To locate and repair them by some inexpensive method is money well spent, both from an economic and public relations standpoint. There will, in all probability, appear another group of pipe failures each year in this old pipe. It will be well to make this leakage survey each summer.

The Thermodynamics Of Partial Pressures

By HILDING V. BECK
Assistant Professor
School of Mechanical Engineering
University of Oklahoma

IN many of the various phases of engineering are found applications of the law of partial pressures; especially is this true in the practice of refining crude oils. A very common and illustrative example of this principle is the moisture contained in air at atmospheric temperatures. Water cannot exist in the vapor state at atmospheric temperatures except at very low pressures. This is the case: the water vapor, superheated to atmospheric temperature, exists at its partial pressure, which when added to the partial pressure of the dry air equals the total barometric pressure. For instance: In a mixture of dry air and water vapor at a temperature of 80 deg. fahr., the water vapor exists as superheated steam. If the relative humidity is such that the vapor pressure is 0.5 in. Hg., corresponding to a saturation temperature of 58.8 deg. fahr., the steam at 80 deg. fahr. contains 21.2 deg. of superheat. If at this time the barometric pressure is 29.3 in. Hg., the partial pressure of the dry air is 29.3—0.5, or 28.8 in Hg.

To understand this important subject thoroughly it is necessary to have a firm grasp on the fundamental gas laws. It will be shown later that Charles' and Boyle's gas laws are the basis of partial pressure computations. It is therefore expedient to approach this subject with a review of the simple gas equations.

Boyle, in 1662, observed that: at constant temperature, the volume of a given weight of gas is inversely proportional to the absolute pressure. This relation, PV = constant, is shown graphically in Fig. 1. Charles, a little more than a century later, added this observation: at constant volume, the absolute pressure varies directly as the absolute temperature. This relation, P/T = constant, is shown graphically in Fig. 2. It is obvious that these two statements may be combined into a single relation, PV/T = constant. The constant equal to this last relation is of interest, being evaluated as MR where M equals the weight of the gas in pounds and R is the specific gas constant equal to 1544/molecular weight. The value for R is definite and is independent of variations of pressure, volume and temperature; for air it is 53.35. The use of this relation is demonstrated with the following problem. Determine the pounds of air contained in 150 cu. ft. at 75 lb. per sq. in. absolute and 80 deg. fahr. (80+460= 540 deg. fahr. absolute).

Fig. 1—Boyle's law

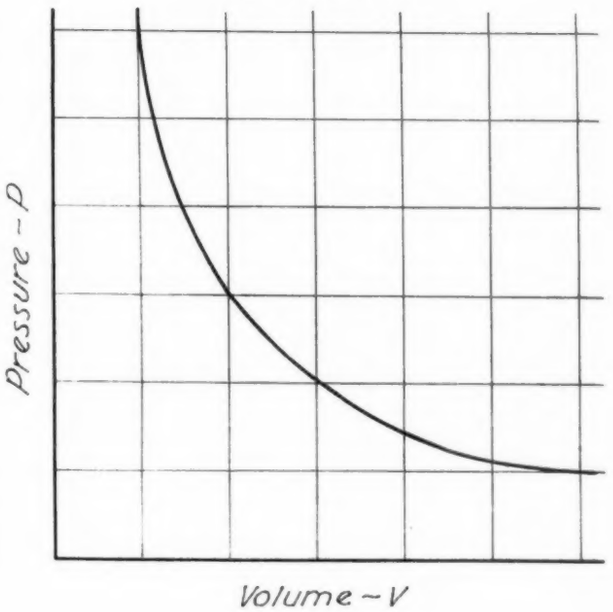
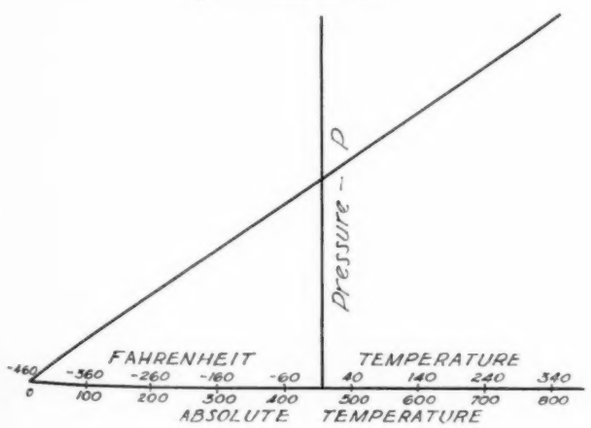


Fig. 2—Charles' law



PV/T = MR, or
M = PV/RT = [(144 × 75) × 150]/(53.35 × 540)
= 56.2 pounds.

It will be noticed that the factors are always changed into the fundamental units; pressure in lb. per sq. ft. absolute,

volume in cu. ft. and temperature in deg. fahr. absolute.

Another important use of this relation is the computation of gas volumes under changed conditions of pressure, volume and temperature. Denoting initial conditions by the subscript "1" and final conditions by the subscript "2", the equations become

$$P_1V_1/T_1 = MR$$
$$\text{and } P_2V_2/T_2 = MR.$$

Since both of these expressions are equal to the same quantity, MR, they are equal to each other, and

$$P_1V_1/T_1 = P_2V_2/T_2.$$

It can be seen that by substituting the pressure and temperature values for the initial and final conditions, the volume under the changed conditions may be determined.

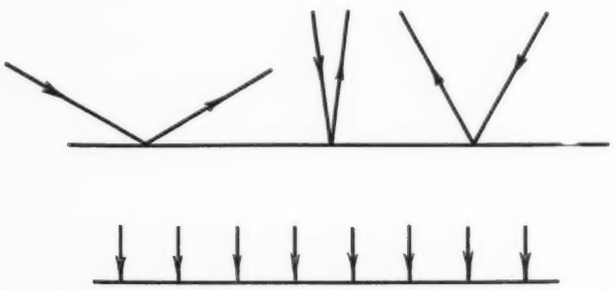


Fig. 3.—Sketch of the possible way in which the molecules strike the containing walls and summation of the impacts produced

The law of the partial pressure of gases is the paradoxical statement that several gases may fill the same volume at the same time; the total pressure of the mixture being the sum of the partial pressures of the constituents. That is, a cubic foot of a mixture of nitrogen and hydrogen at 1000 lb. per sq. in. absolute could be made up of one cubic foot of nitrogen at 75 lb. per sq. in. absolute and one cubic foot of hydrogen at 25 lb. per sq. in. absolute, both occupying the same volume at the same time. As is always the case with gaseous mixtures, the constituents, being in intimate contact, are at the same temperature.

The seeming falsehood or paradox, as expressed in the above law, is explained by our interpretation of the volume occupied by the gas. According to the molecular theory of gases, a gas is a large number of molecules moving at high velocity. The volume actually occupied is extremely small compared with the space in which they move. The case might be compared with our solar system in which the celestial bodies move in space infinitely large compared with their actual volume. Scientists state that the temperature of a gas is a direct measure of the molecular velocity and that the pressure on the containing walls of the vessel is caused by the impact of the molecules striking the walls and rebounding. The summation of these impacts as shown in Fig. 3, cause the pressure observed. Since the space actually occupied is so small, it is obvious that another group of molecules might be added to the same volume. The second gas will strike the containing walls along with first gas and because of its impact will create a partial pressure that will add to the former pressure, increasing the total.

The correlation between this principle and Boyle's and Charles' laws can be shown in the following way: Suppose, as in Fig. 4, three gases at the same pressure, P, are contained in a vessel having a total volume, V. The gases, all at the same temperature, are separated by partitions into their respective volumes V_1, V_2, and V_3. The corresponding weights of the gases are M_1, M_2, and M_3. If the partitions are removed, each of the gases, by a process of diffusion, will expand to occupy the entire volume, V; as though the other gases were not present. Since the expansion is at constant temperature, the pressure of each constituent drops according to Boyle's law. These new partial pressures are denoted by P_1, P_2, and P_3. This may be shown algebraically as follows:

$$PV_1 = P_1V, \text{ or } P_1 = PV_1/V$$
$$PV_2 = P_2V, \text{ or } P_2 = PV_2/V$$
$$PV_3 = P_3V, \text{ or } P_3 = PV_3/V.$$

From these relations it is evident that the partial pressures compare as the partial volumes before mixing; P_1: P_2: P_3 = V_1: V_2: V_3. By adding the quantities equal to the partial pressures it can be shown that the sum of the partial pressures equals the total pressure;

$$P_1 + P_2 + P_3 = P(V_1 + V_2 + V_3/V) = P$$

This deduction has been based upon a constant temperature change in which case Boyle's law applies directly. If the volume would be held constant, allowing the pressure and temperature to vary, the properties of each of the constituents would vary uniformly according to Charles' law.

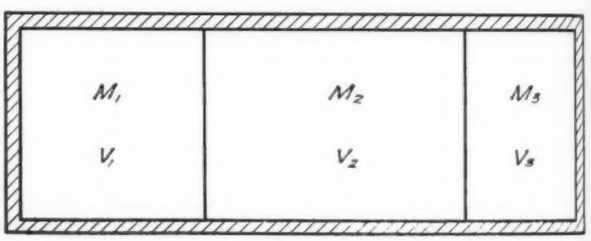


Fig. 4

An interesting example illustrating this principle follows: Determine the weight of water in 1000 cu. ft. of methane saturated with water vapor at 14.7 lb. per sq. in. absolute and 100 deg. fahrenheit. Since the mixture is saturated, the water vapor must be at the pressure corresponding to 100 deg. fahr. as found in the steam tables, or 0.9487 lb. per sq. in. absolute. The corresponding density is 0.00285 lb. per cu. ft., consequently $1000 \times 0.00285 = 2.85$ lb. of water will saturate the gas.

It can be seen, upon some contemplation, that the entire study is a simple one and can be applied to numerous practical problems facilitating computations that would otherwise be quite difficult.

Altering Current Frequency to Vary Speed of Pumping Wells

By
W. C. LANE
Electrical Engineer

THE question has been asked as to whether it is possible to lower the pumping speed of a group of wells driven by a small electric plant by reducing the frequency of the electric current. The idea the questioner has in mind is evidently not whether it is possible to do so but rather what changes in the generating equipment are necessary and what effect a change in the frequency will have on the behavior of the other apparatus involved. The plant in question is to be used exclusively for supplying energy for pumping an oil lease and for the lighting on the property.

The frequency of the current generated by an alternator is expressed as follows:

(1) Frequency = Pairs of Generator Poles × Revolutions per minute/60.

It is obvious that the frequency of the current supplied by a given generator will depend entirely on its speed. On a direct-connected unit this quantity can be changed only by altering the speed of the engine. Two methods are available on a belted unit—changing the speed of the engine and modifying the diameter of the driven pulley. The former method is the more effective as it is more flexible and is the easier to apply, but the limits are narrow. Usually the speed of an engine used on this kind of work can be reduced about 25 per cent below that at which it is adjusted to carry its maximum continuous load. Since the idea is to apply the method during the early life of a field when the pumping loads are light, the load on the engine will not be heavy. It should be able to operate at the lower speed without operating irregularly or giving other trouble. A plant designed for normal operation at 60 cycles will generate 45 cycles at a 25 per cent speed reduction. If lower frequencies are desired it will be necessary to resort to the method of changing the ratio of the pulleys constituting the drive, in addition to altering the speed of the engine.

The ideal speed of a squirrel cage motor can be calculated from Equation (1). Before applying this equation it is well to rewrite it in the following form:

(2) Rev. per Min. = (Frequency × 60) / Pairs of Motor Poles.

The number of poles on a standard motor is fixed when it leaves the winding room at the factory. Equation (2) states that the speed of a motor is directly proportional to the frequency of the current used to drive it. Special motors can be purchased that have an adjustable number of poles, thus giving them as many as four distinct speeds, but these are not recommended for an installation of this kind. By nature they are rather complicated and have poor operating characteristics when operated at some of their ratings.

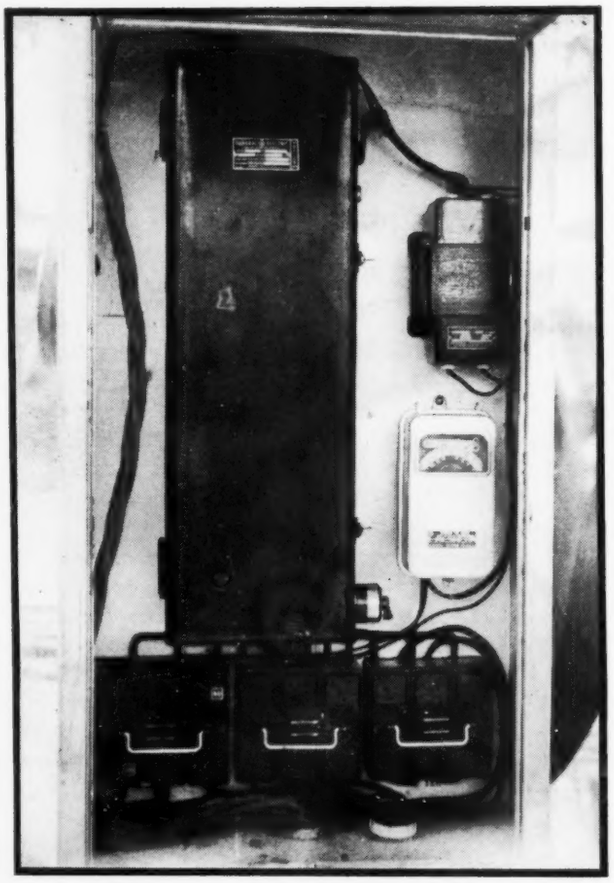
The so-called ideal speed of a motor obtained by applying Equation (2) is always higher than the actual speed under load by three or four per cent by reason of the losses inherent in a motor. For example, a six-pole motor will be rated at 1160 r.p.m. on 60-cycle current. The same motor will run at about 860 r.p.m. when the frequency is reduced to 45 cycles. Incidentally the limit of the highest speed it is possible to obtain with a motor on 60-cycle current is always below 3600 r.p.m. since one can not have less than one pair of poles.

The item of efficiency does not occupy a prominent place in a set-up of this kind. This is because gas usually is plentiful and of little commercial value during the early life of a field at the time when the power demand is small. Saving gas and then burning it in a flambeau is quite different from economizing on gas actually purchased from a pipe line. The major items of expense in connection with the operation of a plant are more or less fixed and are independent of the load. For this reason the principal thing with which one is concerned is the effect of the proposed method of operation on the generating unit and on the motors, line starters, time switches and other apparatus on the lease.

From the standpoint of an electrical engineer it is the best practice to keep the voltage at its normal value in order to avoid increasing the losses in the distribution system. If this is done several objectionable features will be introduced. At the power house it will be necessary to over-excite the generator fields as the voltage will fall in proportion to the speed reduction unless the field current is increased. The increased load on the exciter at the reduced speed will probably cause it to overheat. If a voltage regulator is in use it will be necessary to reset it, an operation that should not require the services of an outsider if the operator of the plant has been given a little instruction concerning it.

Probably the first trouble to be encountered at the wells will be that the hold-in coils of the magnetic line starting switches will burn out. This will result from the decrease in the frequency. The obstruction offered by a coil of wire to the passage of an alternating current is dependent largely on this factor. The effect on the operation of the motors will be as follows:

1. The speed will decrease in proportion to the decrease in frequency.
2. The magnetizing current that determines the power factor will increase.
3. There will be an increase in the magnetic flux.
4. The starting and maximum torques will increase.
5. The power factor will usually be lower by reason of the increase in the magnetizing current.
6. The efficiency will probably be lower.



7. Since the ventilation is poorer at the lower speed and the losses are slightly higher, the temperature for a given load current will increase.

The gist of the effects listed above from the operator's standpoint is that for a marked decrease in frequency, a motor will be unable to carry its rated load without heating abnormally. Also, trouble will be experienced with the starting apparatus and with the clocks on the time switches if such are in use. It may be said that the effect of lowering the frequency is similar to that produced by raising the voltage. This is the reason why 440-volt 60-cycle motors sometimes give trouble when operated on a 50-cycle 480-volt circuit.

A better method to follow is to lower the voltage in proportion to the change in frequency. Under this condition the magnetic flux in the iron will remain constant and the starting and the maximum torques will be unchanged. The full load torque will be produced under practically the same current conditions as those that exist under normal frequency and voltage operation. However, it must not be forgotten that while the normal rated full load torque is available, the speed is lower. The horsepower developed by this torque will be reduced in proportion to the reduction in frequency.

As an example of this principle take a 25-hp. 440-volt 60-cycle motor and operate it at 45 cycles and 330 volts. The horsepower developed by the rated full load current will be $45/60 \times 25$, or $18\frac{3}{4}$ horsepower. If a motor is to be run at a reduced frequency at its rated horsepower the voltage should be changed as the square root of the frequency changes. In the motor cited above the voltage for operating a 440-volt 25-hp. 60-cycle motor at 25 hp. and 45 cycles should be $440 \times 45/60$, or 380 volts.

• An individual well control panel that • permits instantaneous changes in motor horsepower ratings and automatic operation of • wells by means of an electric time switch •

Since the losses are the same and the power developed is less, both efficiency and power factor will decrease slightly and the temperature will be somewhat higher as a result of the poorer ventilation. It was stated elsewhere that on such an installation as this one in mind, slight changes in efficiency and power factor are of little importance. There is no doubt about the adaptability of motors to operate at a reduced horsepower at the lower frequency. The closing coils of the line starters will not be damaged and the switches will doubtless remain closed since the current passing through them will tend to remain constant.

Where provisions have been made for starting and stopping the wells by means of time switches actuated by electric clocks, the result will be that the calibration will be incorrect. It will take the same number of cycles in each case to cause the dial to move the space marked one hour. If the clocks are calibrated on a 60-cycle circuit they will require one and one-third times as long to move the dial over a given space on a 45-cycle circuit. The torque produced by the clock motors should not change materially under the reduced voltage, so clock trouble should not be experienced.

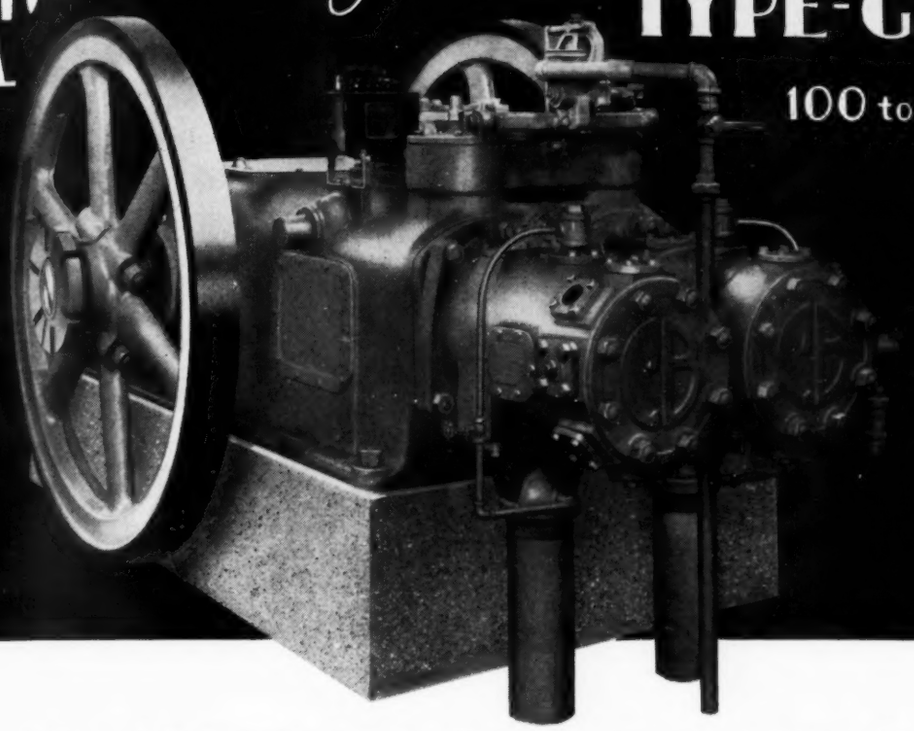
Electric power lines are always designed to carry the heaviest load anticipated. It follows that during seasons of light power demand the voltage drop will not be excessive. At the power house it will be found that the generator field current will be the same as it was for 60-cycle normal voltage operation. The load on the exciter will be unchanged with the exception that the field current will be increased in order to maintain the exciter voltage at the reduced speed. This statement is based on the assumption that the exciter is driven from the shaft of the main generator. As to the carbon pile voltage regulator, the currents through the actuating coils will not change materially but some adjustment will probably be necessary.

The lamps on the lease will naturally burn a dull red at the subnormal voltage and if the frequency is very low they will pulsate. In case the lighting problem is regarded as a matter of much importance it can be solved by purchasing lighting transformers having an extra secondary tap that will give the correct voltage ratio. This will not increase the cost materially.

It appears that the idea has enough merit to justify designing engineers in making the few simple provisions necessary to apply it. Much unnecessary wear and tear on pumping equipment due to excessive speed can be eliminated. Where it is planned to install a belted unit it is a simple matter to make provisions for adjusting the belt tension of the generator drive so as to provide for the resultant change in the shaft centers. This is really the only feature in the design that requires special attention. The speed adjustment on the engine is provided by the engine manufacturers.

Announcing the NEW TWIN COOPER-BESSEMER TYPE-G.A.W.

100 to 140 H.P.



OIL FIELD operators familiar with the advanced engineering features of the twin cylinder Type G. A. U. have asked for a larger engine of exactly the same design. Sixty to one hundred B. H. P., which is the rating of the G. A. U., wasn't big enough for some of the largest geared pumping powers and other oil field jobs.

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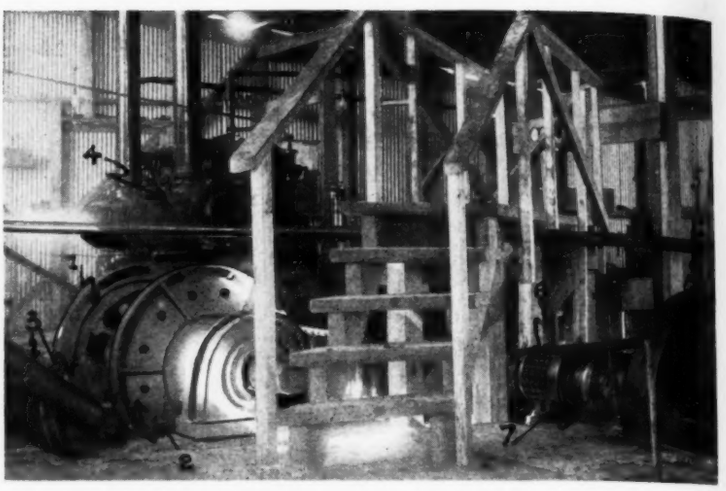
« By K. C. SCLATER »

Wildcatting in Mexico With Modern Equipment

A WILDCAT well differs in several important respects from a drilling well in a proved area. Being a prospect well it may be in an isolated region where transportation and related problems having a vital bearing on the equipping and drilling of the well call for careful forethought and planning. There is always uncertainty regarding the physical character, thickness and depth of the formations to be penetrated, and the subsurface pressure and other physical conditions that may be encountered should gas, oil, or water be struck. If the well is a deep test in a little-known region it increases the necessity for making ample provision to meet contingencies. Regardless of whether or not a commercially productive well results, a wildcat to be successfully completed implies that it shall yield valuable information of the kind disclosed only by drilling, information that should serve as a reliable guide for future exploration and development work. Hence the importance of bestowing care in the selection of drilling machinery and equipment to meet the known local conditions, for it offers the surest means of accomplishing the successful completion of the hole as economically as the existing local conditions will permit. These considerations explain why the most modern types of drilling machinery and methods are to be found in use on wildcat wells in the most remote localities.

Just such a wildcat well is the Mexican Gulf Oil Company's San Ambrosia No. 1 in the State of Nueva Leon, Mexico. It is some 45 miles southwest of Laredo, Texas, in a wilderness of mesquite and prickly cactus where water is scarce and suitable fuel has to be transported a long distance. As this wildcat is to be a deep test, here are to be found power machinery and drilling equipment of the most modern type, the general lay-out and details of which arouse immediate interest.



Sheldon-Burden Transmission

(1) Forward clutch. (2) Reverse clutch. (3) Clutch air-control cylinders. (4) Drilling engine. (5) Pump engine. (6) Quadruple chain drive to pump. (7) Pump engine clutch lever

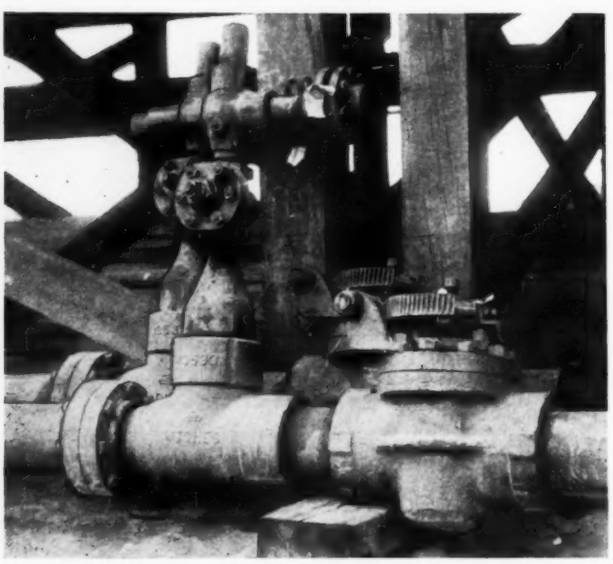
A Sheldon-Burden double Diesel engine power transmission is used to drive a conventional 4-speed drawworks, a 27-in. rotary, and a 7¼x14 slush pump. Only one slush pump has been installed, as no trouble from caving or sand-cutting is anticipated. An auxiliary pump may be installed later for cementing and other odd service around the derrick and also as a standby in an emergency.

Of mechanical interest is the Sheldon-Burden double Diesel engine hook-up that comprises the power end of the drilling machinery. Two large Diesel engines are coupled to a forward and reverse clutch unit with quadruple chain drives. Looking from the derrick floor, the Diesel engine on the left, called the drilling engine (see accompanying sketches), operates so as to give a forward motion to the drawworks and rotary table. The Diesel on the right, called the pump engine, operates the pump drive shaft through a quadruple chain drive in a manner such that it may also be used for the reverse movement of both the drawworks and the rotary table. As this reverse movement is used only for very short periods during general drilling operations, there is no need to disconnect or slow down the slush pump.

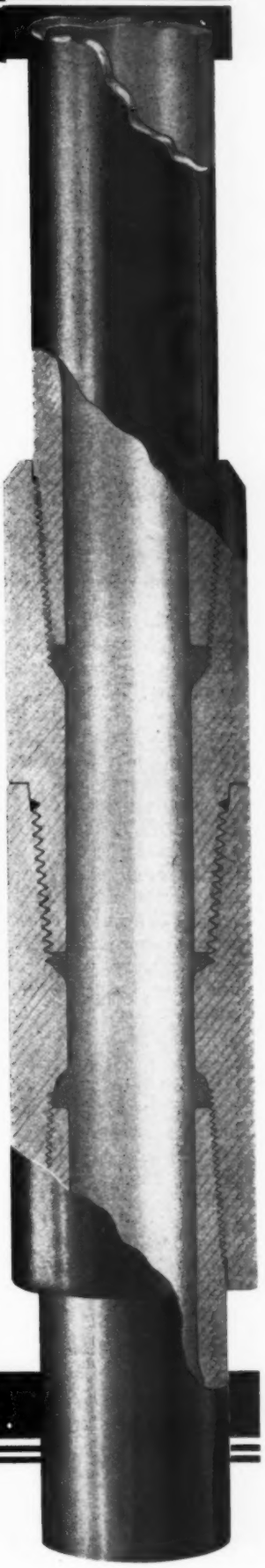
A one-to-one gear box between the power take-offs permits coupling the two engines for hoisting when coming out of the hole. Coupling of the engines is accomplished by means of a jaw clutch inside the gear box. The gears are large, of herringbone type, remain always in mesh, and run in one direction in oil.

(Continued on Page 32)

Flow line chokes and connections made up for placing on well when required



REED FULL HOLE TOOL JOINTS



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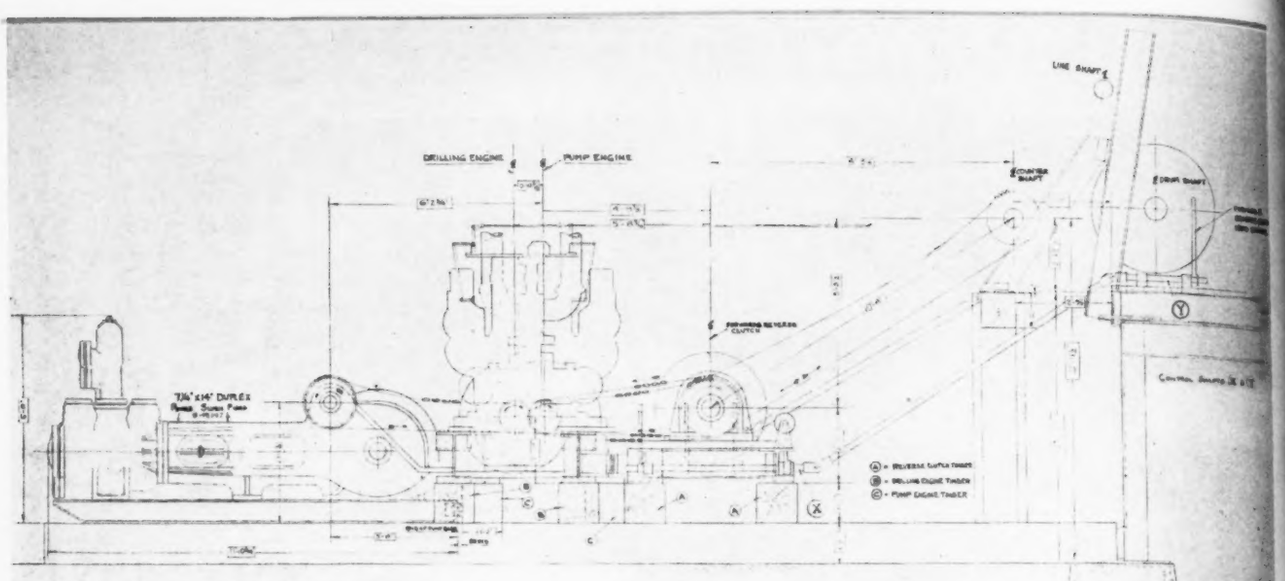


END ELEVATION
SHELDON-BURDEN DOUBLE DIESEL ENGINE DRIVE

When both engines are coupled for hoisting, the pump drive is disconnected through a jaw clutch, thus making available the power of the two engines on both the forward and the reverse drive of the clutch assembly. Power is transmitted from the double engine hook-up by quadruple chain drive to the clutch unit.

Two large friction clutches are mounted on the drive shaft and are engaged and disengaged by one control level. The driven elements of the friction clutches are keyed to the clutch drive shaft, from which power is transmitted to the line shaft of the drawworks by a quadruple chain and sprocket mounted on the outboard end of the shaft. Forward, reverse and neutral are obtained by the turn of only one control lever; and an air-operated control insures smooth, easy engagement and disengagement of the clutches. Maximum flexibility, which provides all engine combinations for slush pump, hoist and rotary both in forward and reverse, is the chief feature of this power transmission hook-up.

The two 36-in. Twin Disc clutches in the clutch unit have a capacity of 480 hp. each. The drive from the engine take-off to the clutch unit consists of two quadruple-width machine-cut multiple-tooth sprockets mounted in a cast-steel friction clutch carrier rotating on large Hyatt bearings.

Two 10x12½, 240-hp., 425-r.p.m. 6-cylinder, 2-cycle Fairbanks Morse type 44H full Diesel engines are employed as the prime movers, and are equipped with a Curtis 3¾x4 built-in air compressor for the operation of the clutch controls. The engine exhaust manifolds are water-jacketed and equipped with pyrometers for indicating exhaust temperatures. Standard air tanks, air-filter adapters with air filters and auxiliaries for charging are also provided. The engine controls from the driller's position to the engine are either single or dual.

Mirando crude is used as fuel and has to be transported almost 100 miles to the well. On shop tests the engines showed a fuel consumption of about .04 lb. per hp-hr. under full load. Under light load at the well the operating temperature of the exhaust was observed to be about 250 deg. fahrenheit. Under full load, 450-540 deg. fahr. is the working temperature range of the exhaust.

Both engines have friction clutches on the power take-off and, between the double engine hook-up assembly and the engines, a Fast flexible coupling to allow for any slight misalignment. The power controls consist of only two levers and these are so placed that the driller from his position can conveniently handle either one or both engines with the same ease as that of the conventional steam-driven rig.

Each engine out-board shaft is equipped with a sprocket for the quadruple width chain drive to the clutch unit.

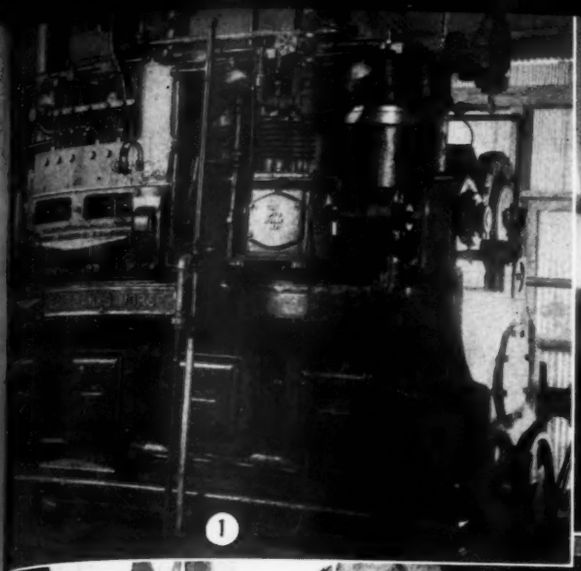
Both engines and the clutch unit are mounted on machine-riveted arc-welded structural steel base units, each of which, including the pump drive, is machined on the surface, thus insuring their alignment in the field.

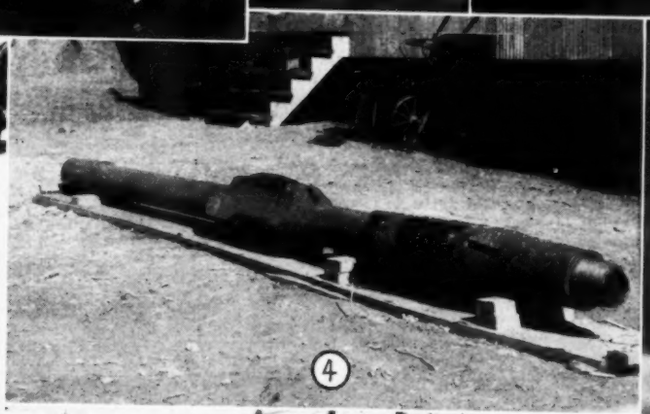
An Emsco HRB, 4-speed, 3-shaft drawworks, with double cathead and an extension on the drum shaft to take a Parkersburg 36-in. Model B Hydromatic brake, has a sprocket for the quadruple chain drive mounted on the jack shaft. The use of a Hydromatic brake is expected to eliminate braking troubles and to speed up operations when the deep drilling stage is reached.

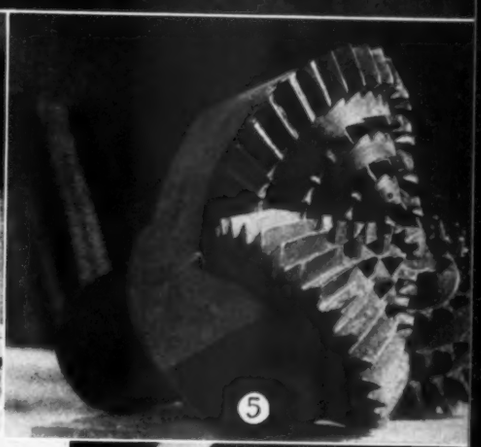
An Ideco-Boykin 27-in. Superior make-and-break rotary completes the power equipment. It has a 14-tooth sprocket, a 10-tooth pinion and a 60-tooth rotary table. The table runs on ball bearings and the shaft in roller bearings.

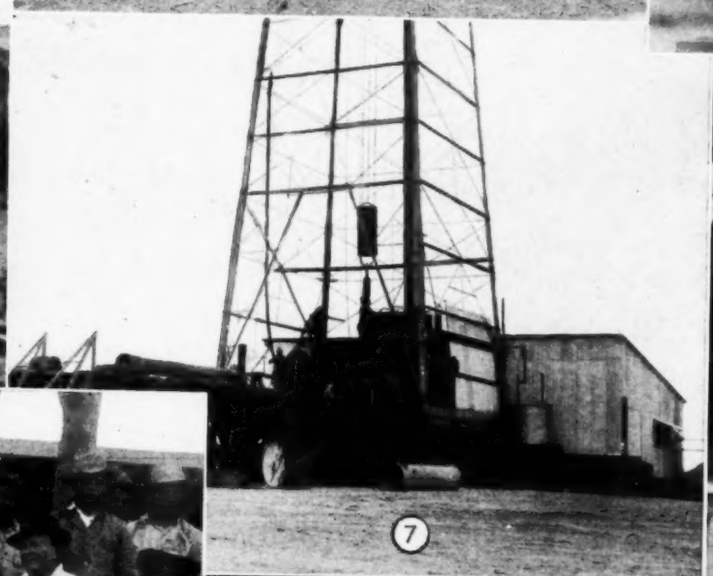
KEY TO PICTURES ON OPPOSITE PAGE

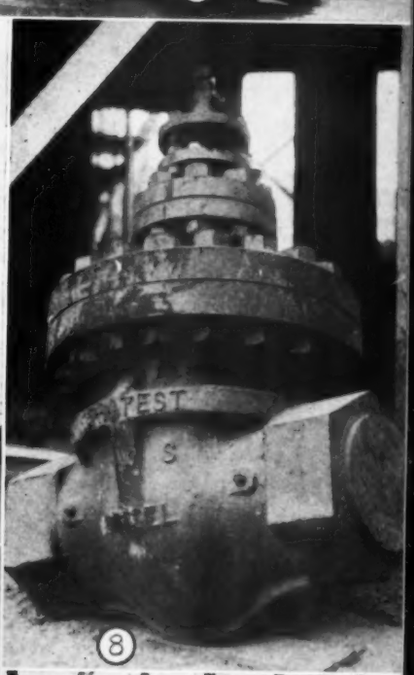
Picture No. 1—Front view of one of the 240-hp. Diesel engines. Note the built-in air compressor on the upper right of the engine. *Picture No. 2*—H. D. Coles, production and drilling superintendent, Mexican Gulf Oil Co., Tampico, Tamps, Mexico. *Picture No. 3*—Power slush pump and discharge connections. (1) Spring pop valve. (2) Shear relief valve. (3) Discharge relief line. (4) 8-in. by 4-ft. air-chamber extension. (5) Discharge line to rotary swivel. (6) Barco union on mud pump discharge. (7) Eclipse lubricator. *Picture No. 4*—Hughes double-stage three-point 14-in. forged-steel reamer. *Picture No. 5*—Hughes three-cone roller bearing, rock bit to be used on the well. *Picture No. 6*—One corner of the derrick showing: (1) Weight indicator and recorder; (2) Weight indicator diaphragm attached to dead-line; (3) Flood light for casing rack and runway; (4) Method of securing dead-line without kinking it; (5) Dead-line to reel; (6) Casing for break-out tong counterbalance weight. *Picture No. 7*—Small tank on right of derrick is the 15-bbl. supply tank for Hydromatic brake. *Picture No. 8*—10¾-in. 6000-lb. test drilling gate valve to be used on the well. *Picture No. 9*—Members of the drilling crew: (1) T. R. Bibee, driller; (2) G. H. Hildingson, tool dresser; (3) G. L. Blalock, driller; (4) W. D. McCally, Fairbanks-Morse service engineer; (5) A. Palacios, roughneck; (6) Frank Baquet, tool dresser; and five Mexican roughnecks. *Picture No. 10*—Blowout preventer for 10¾-in. casing with two 7-in. flow line connections and 4½-in. O. D. self-centering rams. *Picture No. 11*—All controls are convenient to driller's station. In this picture can be seen the Hydromatic brake, and (1 Diesel engine throttle lever. (2) Air-control lever for transmission clutches. *Picture No. 12*—Ready to resume drilling after setting surface casing. Note method of centering grief stem to insure vertical hole.

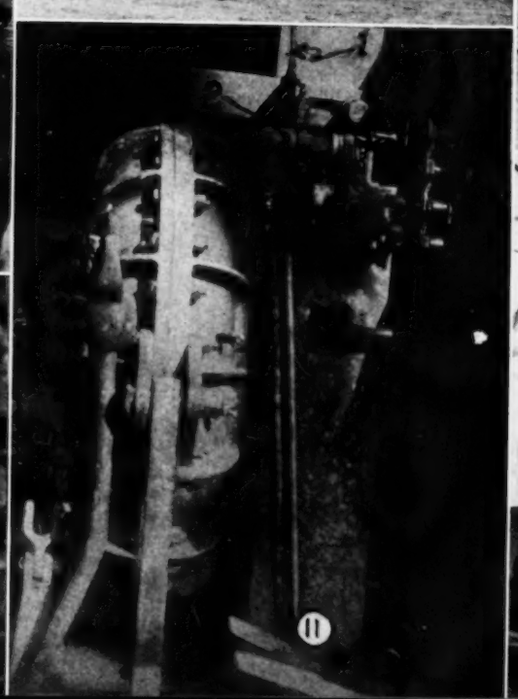


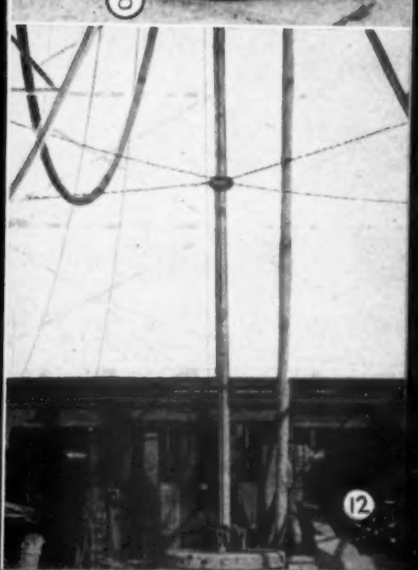


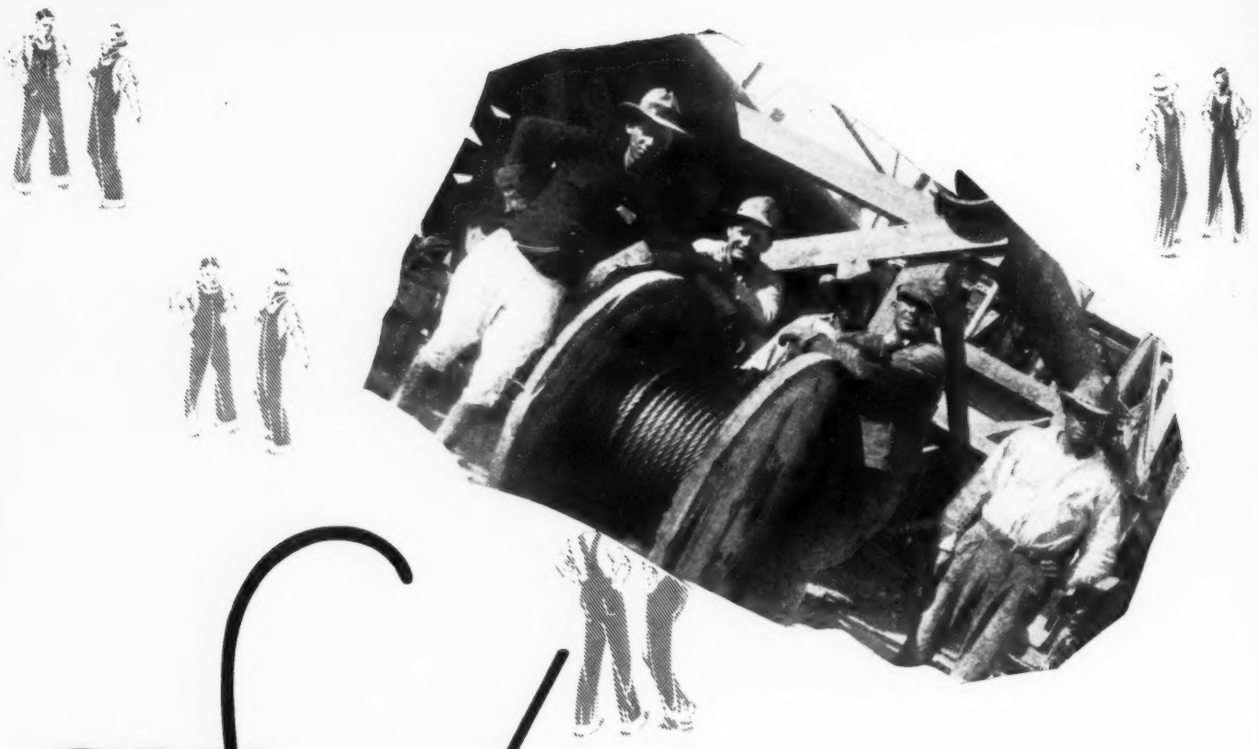












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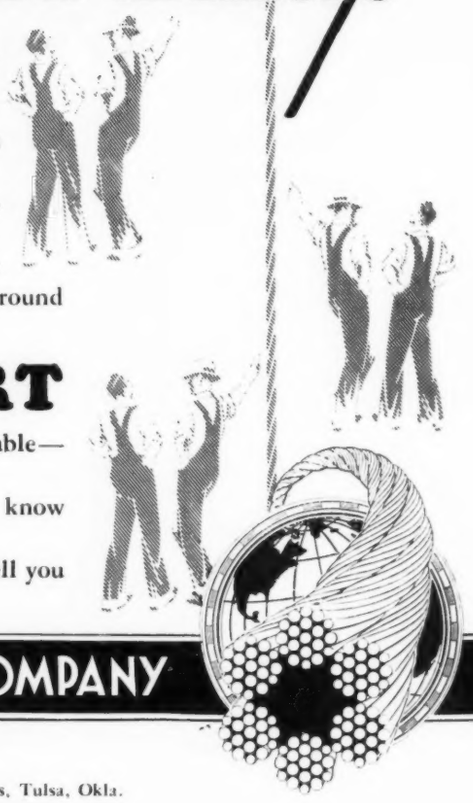

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The well was spudded in on December 28, 1933. Only about 40 ft. of surface casing was to be set, but trouble with boulders necessitated carrying the 20-in. to 140 ft., where it was set and cemented with 100 sacks of cement on January 9, 1934. Drilling was resumed January 11 and is now in progress in an 18-in. hole.

The casing program at present calls for 600 ft. of 16-in. 65-lb., range 1, Spang-Chalfant lapweld casing, and from 2500 to 3500 ft. of 10¾-in. O. D. 45.50-lb. 8-thd. A.P.I. grade D, range 2, seamless steel casing. Spang-Chalfant Simancro casing tested to 1900 lb. will be used for the 10¾-in. string.

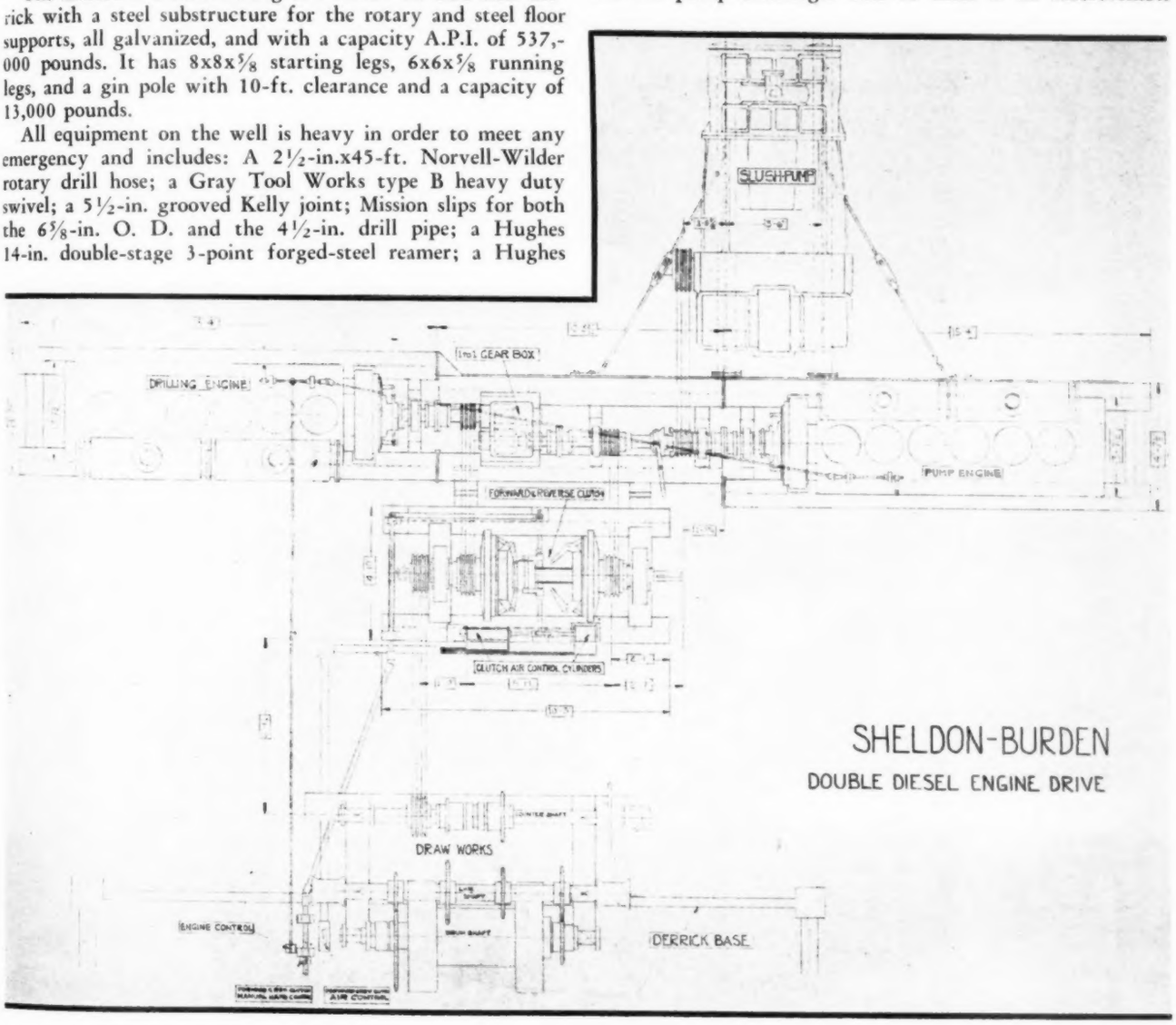
It is planned to drill to 2500-3500 ft., to where the 10¾-in. will be landed, with Jones and Laughlin 6⅝-in. O.D. 25.20-lb. A.P.I. seamless full upset end drill pipe, with Reed full opening A. P. I. tool joints. After the 10¾-in. casing has been set a change will be made to 4½-in. 16.60-lb. flush joint drill pipe, 2500-lb. test, with Doheny-Stone tool joints on each joint.

Most of the drilling from the surface down to where the 10¾-in. casing will be landed is expected to be done with fish-tail, Appleman type, bits. But from this point on it is anticipated that it will be almost entirely hard rock drilling, for which service both Reed roller bearing and Hughes three-cone roller bearing rock bits have been specified. A 136-ft. steel derrick on the well will allow stacking the drill pipe in fourbles.

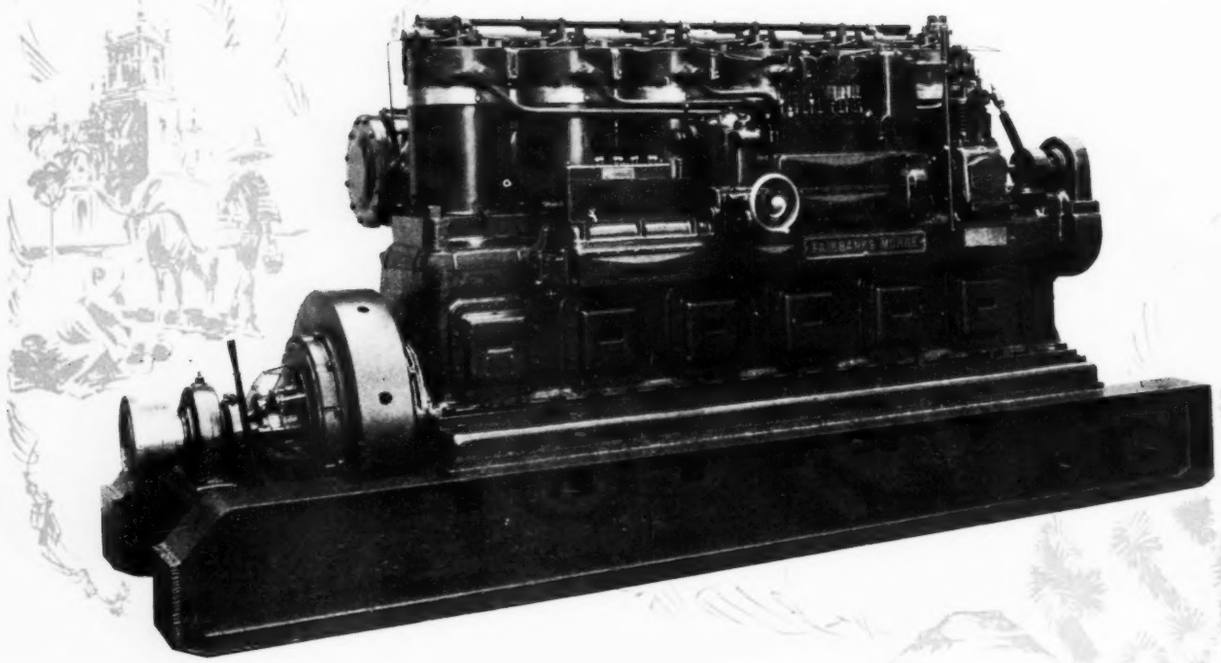
The derrick is a Parkersburg 136-ft.x26-ft. base steel derrick with a steel substructure for the rotary and steel floor supports, all galvanized, and with a capacity A.P.I. of 537,000 pounds. It has 8x8x⅝ starting legs, 6x6x⅝ running legs, and a gin pole with 10-ft. clearance and a capacity of 13,000 pounds.

All equipment on the well is heavy in order to meet any emergency and includes: A 2½-in.x45-ft. Norvell-Wilder rotary drill hose; a Gray Tool Works type B heavy duty swivel; a 5½-in. grooved Kelly joint; Mission slips for both the 6⅝-in. O. D. and the 4½-in. drill pipe; a Hughes 14-in. double-stage 3-point forged-steel reamer; a Hughes type C core bit with an 18-ft. sectional core barrel; a Williamsport 1550-ft. 1⅛-in. 6x19 steel drilling line; an Ideco-Boykin type L R 6-sheave crown block with sheaves grooved for 1⅛-in. line complete with swivel cathead attachment; an Ideco-Boykin 72-in. roller bearing traveling block; a 150-ton B-J drill hook; B-J Wilson Triple X elevators; B-J 2½-in.x84-in. weldless links; B-J Wilson tongs; a Petol Gearench; and a Hill & Foster automatic cathead. Casinghead connections consist of a Kerotest 10¾-in. type S, 6000-lb. test, drilling gate valve and a 10¾-in. type M R Cameron Iron Works blowout preventer with 4½-in. O. D. self-centering rams and two 7-in. side openings for flow lines. Two 7-in. flow lines with chokes and 7-in. Merco Nordstrom plug valves will also be used for well control purposes.

The mud circulation system on the well is carefully designed and is patterned after the standard mud system in use by the Gulf Production Company in the fields of the Gulf Coast. A 7¼x14 Imperial 14-P Oilwell mud pump, equipped with a quadruple drive sprocket mounted on the shaft, and mounted on heavy steel beams that are securely tied into the engine and transmission clutch unit timber foundations. It has a 12-in. suction. To prevent water hammer, two extra air charbers are installed on the mud pump discharge. One, 8 in. x 4 ft., is installed above the pump air chamber and the other, 8 in. x 16 ft., is installed on the upper end of the mud pump stand pipe in the derrick. To prevent damage by high pressure there are two relief valves on the pump discharge. One of these is an Abercrombie



FAIRBANKS
DIESELS



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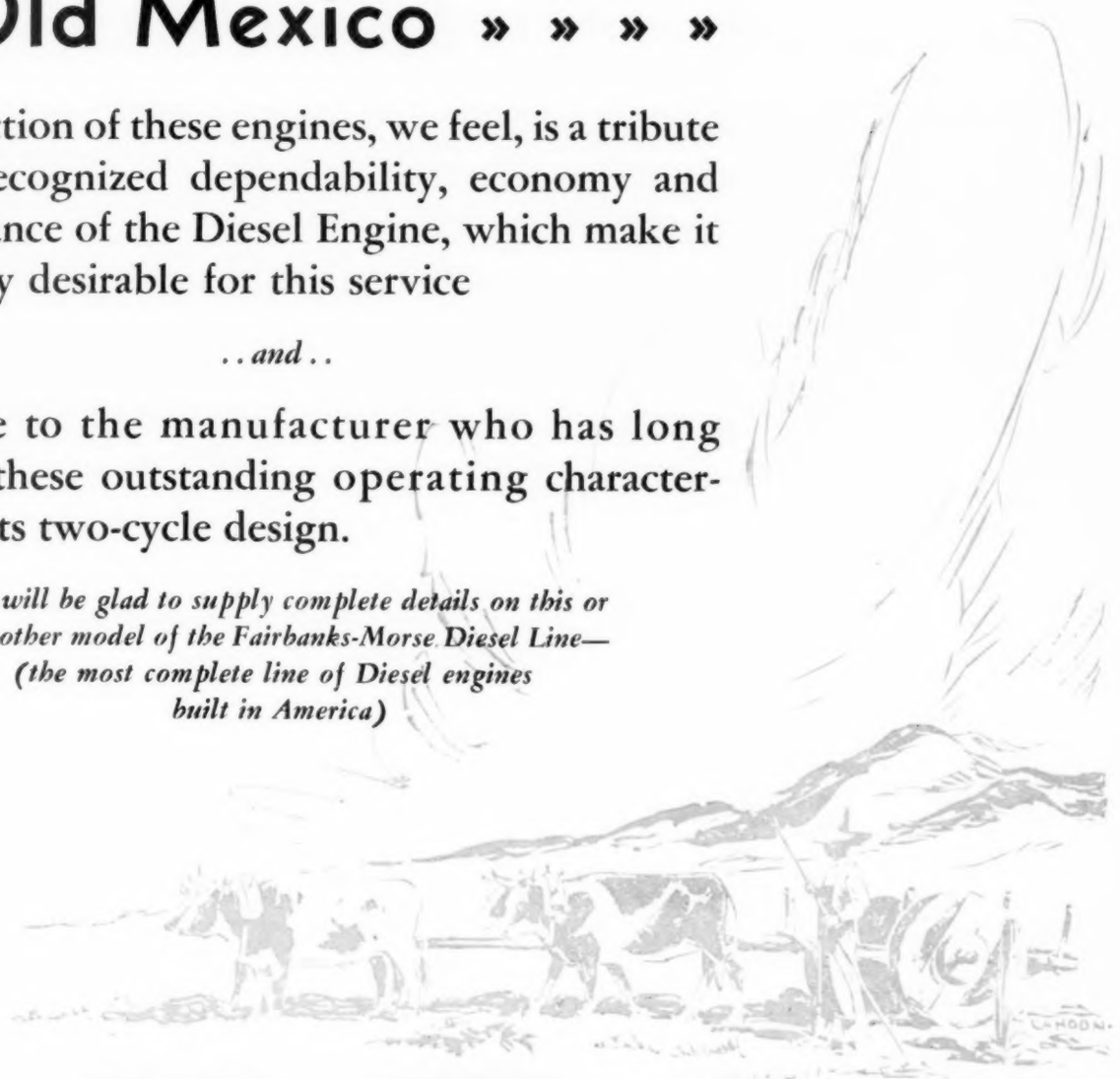

ENTAL

Pump Company Shear relief valve. Merco Nordstrom plug valves and Barco unions are used throughout on the mud system. The mud pump is equipped with an Eclipse mechanical lubricator and with Mission valves and pistons.

There is a reinforced concrete cellar, 10 ft.x10 ft.x14 ft. deep, with 8-in. walls and a 2-ft. floor. Two of the walls have two 15-in.x 24-in. pilasters each, to carry the heavy steel beams of the derrick substructure. Concrete foundations have been placed at the derrick corners and intermediate concrete footings set for the substructure.

Precautions are being taken to guard against a crooked hole. A 10-in. laced joint 30 ft. long, made by welding 10-in. casing over 6-in. casing, is being used on the drill stem just above the fish-tail bit. It has four couplings, one every ten feet, each of which is hard-surfaced with Hastellite. On top of the laced joint four cutting lugs are welded on the outside. These also are hard-surfaced with Hastellite and serve as a bit in case cavings or a bridge make it necessary to rotate out of the hole. A 2-in. hole is drilled in the bottom and in the top coupling of the laced joint and provide a passage for the mud through the annular space of the laced joint, thus reducing the danger of hydraulicking the walls of the hole when the circulation clearance is small.

The well will be surveyed for verticality at 100-ft. intervals by means of a type A Syfo Clinograph. This instrument will be run on a Halliburton steel line with a measuring reel, which will be equipped with a 2-kw. 110-v. D.C. motor for pulling the Clinograph out of the hole.

Corner of derrick showing mud pump pressure gauge, break-out tongs, and casing for break-out tong counter-balance weight. Also drill pipe and Reed joints.

Even the lighting system on the derrick is modern, for the derrick is wired with "String - A - Lite" safety lighting cable, a product of the Sullivan Machinery Company. A Kohler lighting unit supplies the current.

Numerous labor-saving devices and safety features are on the well, as for example: housings for breakout tong counterbalance weights; the method of attaching the dead line to prevent kinking; spooling pulleys and weights for the drilling line; a hay-rake finger board in the derrick for stacking the drill pipe; a Hills McCanna pressure pump and manifold for lubricating the crown block sheave bearings from the derrick floor; and a Garrett Brass Works safety slide for the derrick man.

Everything on and about the well reflects careful, systematic preparation. Many different pieces of modern machinery and equipment have been selected and combined into a compact drilling unit, the performance of which it will be interesting to watch.

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W. L. NELSON
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Editors

Elements of Applied Production

Article 3

EQUIPMENT AND OPERATION OF OIL WELLS

(Continued)

By K. C. SCLATER

Naturally Flowing Wells—(Continued)

BY pressure control of an oil well is meant the adjustment of pressures within the well in order to obtain the most efficient and economic utilization of natural gas energy with a minimum of danger from water encroachment and sand troubles. Pressure control is also known as back-pressure control.

Pressure control may be applied by the restriction of flow through tubing of the proper size and depth, by the use of flow beans, by the modified use of the gas-lift, by the spacing of pumps (in pumping wells), by the control of fluid levels in the well, and by the use of special flow or pumping devices. Since in this article we are dealing with naturally flowing wells, pressure control will be discussed as it applies to wells of this type.

Perhaps gas-oil ratio and related terms should be more explicitly defined. Originally the gas-oil ratio was termed the gas factor. Today, in its most common usage, it is defined as the volume of gas in cu. ft. produced with a barrel of oil. It is sometimes necessary to qualify the gas-oil ratio by the words: Natural, Formation, Inlet or Outlet, the meaning of each of which will be defined. The term Gas-Liquid ratio is applied to the volume of gas in cu. ft. produced with a barrel of fluid (oil and water).

The Natural gas-oil ratio is the volume of gas in cu. ft. from the productive sand produced with a bbl. of oil, and the term may be applied to oil produced by repressuring or by other secondary methods of recovery. In gas-lift wells the Natural gas-oil ratio is also called the Formation gas-oil ratio and is equal to the Outlet gas-oil ratio minus the Inlet gas-oil ratio.

The Inlet gas-oil ratio is the number of cu. ft. of gas discharged into a well produced by artificial gas-lift, per bbl. of oil produced.

The Outlet gas-oil ratio is the total volume of gas in cu. ft. per bbl. of oil produced from a well produced by artificial gas-lift and is sometimes called the Gas-lift gas-oil ratio. It includes the Inlet and the Natural, or Formation, gas-oil ratio.

A flow bean is the name given to a restriction placed in any part of the flow string of a well to control the rate of flow of gas and oil therefrom, and is sometimes called a choker, a choke nipple, or a flow nipple.

In making flow tests on a naturally flowing well to determine the best rate of production and the corresponding gas-oil ratio, certain precautions should be observed. Satisfactory adjustments to obtain the desired rate of flow can easily be made after testing if the tests are made with reasonable accuracy. Care should be taken to see that there are no leaks at either the tubinghead or casinghead. A slight leak in the casinghead, for example, may greatly influence the flow of the well. It also will be quite wasteful of gas and precious gas energy. In large wells where the gas is ample in volume and pressure, the leak may go un-noticed simply because no immediate harmful effects can be observed; and in wells where the pressure is not very high and the gas volume is small a leak at the casinghead may cause sufficient loss of gas and gas pressure to prevent the well producing by natural flow. When a packer is run on the tubing, the pressure on top of the packer between the casing and the tubing should, if the packer has been securely set, have no influence on the flow of the well. To obviate the possibility of gas or oil leakage, where such is suspected, past the packer from below, an effective liquid seal may be obtained by a column of water on top of the packer in the annular space between the tubing and casing. The length of the water column should be about sufficient to balance only the pressure on the under-side of the packer.

When an adjustment of flow-bean opening has been made, care should be taken to continue the test until the rate of flow becomes reasonably steady and uniform, in which case the

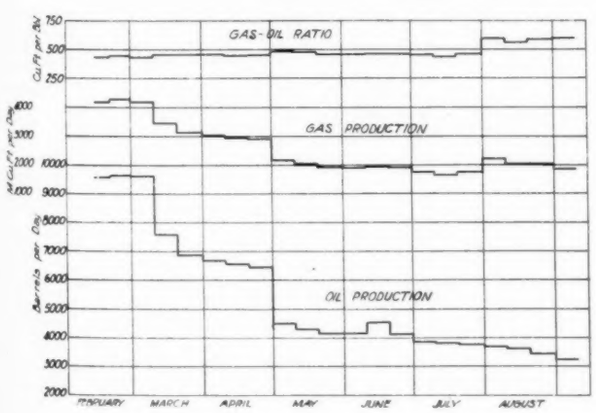

Fig. 4—Production and gas-oil ratio curves of naturally flowing well in Seminole field produced under pressure control

flow conditions in the well are assumed to be in equilibrium. Some wells reach a condition of equilibrium quickly within several hours after a change in flow-bean opening has been made, others take days to reach equilibrium. With wells of the latter type a good course to follow in making flow tests is to start with a large flow-bean opening, then change to a small flow-bean opening, after which a test should be run with a flow-bean opening about midway between the first two. In this way the work of making the flow tests will be expedited, as an approximate estimate may then be made of the rate of flow that will give a minimum gas-oil ratio and likewise the range of bean openings within which the remaining flow tests should be conducted.

Flow tests may then be made, starting with the largest bean opening within the range selected, and a series of tests made down to the smallest bean opening within the range, and then back again to the largest bean opening.

It may not always be possible to obtain a point of minimum gas-oil ratio in a well. Wells display different flowing characteristics. Some wells show little or no decline under restricted or controlled flow; others may show little or no change in the rate of decline under either restricted or unrestricted flow; still others may actually show a greater rate of decline under restricted flow than under unrestricted flow. Such characteristics may result from various conditions as: too open (permeable) a producing sand; too slow a rate of flow; large reservoir content of oil and gas compared with rate of total withdrawal; or a very strong water drive in the reservoir.

Wells that actually show a greater rate of decline under restricted flow than under unrestricted flow are more rare than the other types. Such a characteristic could, for example, be due to the clogging up of sand pores with fine silty material because of the velocity of flow through the sand under restricted flow not being great enough to enable the oil and gas to carry this material into the hole. Close observation of the well will occasionally give a clue to its peculiarities and suggest a remedy for overcoming them should they give trouble.

Measurements of oil and gas produced in flow tests should be made over corresponding periods, and both oil and gas should be measured at the same time. There should also be some degree of consistency in the accuracy of both measurements. Where possible an effort should be made to measure the gas with the same degree of accuracy as that of the oil. What constitutes a reasonable degree of accuracy will depend on the volume handled. For example, in a well producing at the rate of 100 bbl. an hour an error of five bbl. in the hourly gauge would be only five per cent, but producing at the rate of 25 bbl. an hour the error would be 20 per cent.

Likewise, in making gas measurements care should be taken to obtain a reasonable degree of accuracy. A measurement of the gas passing through the orifice meter can be made accurately enough, but a common source of error is the failure to take into account the pressure and temperature under which the gas is separated from the oil. Failure to observe the pressure held on the trap will give a lower gas-oil ratio than actual because of the gas in solution in the oil at the trap pressure and temperature. A correction should be applied. As in the case of gauging the oil the accuracy of the gas measurement should depend on the volume. Failure to take into account the trap pressure may result in a serious error if the gas volume and the gas-oil ratio are small. In comparing gas-oil ratios of different wells, discrepancies often arise due to the measurements being of different degrees of accuracy. This is more likely to be the case when comparing wells of different companies, because of variations in procedure, care and equipment used in making the measurements.

Controlling the flow by means of one or more flow-beans is the most widely used method of applying pressure control to oil wells, and is by far the most practicable and successful method yet available. It is the accepted standard practice to place the flow-bean in the flow line close to the well head and upstream from the oil and gas separator. On a large well the flow-beans comprise an important part of the Christmas tree connections. On large high-pressure wells they are usually installed in duplicate and may be used either singly or together to control the flow from the well. In deep wells in the Kettleman Hills field, California, two or more adjustable flow-beans are included in the casinghead hook-up.

Flow-beans are of three general types; non-adjustable, adjustable, and removable. The latter is the bottom-hole type of choke that can be placed at any desired point in the tubing of the well and removed, or replaced, without disturbing the tubing.

In the testing of wells, the adjustable type of bean is in most general use. Not only is it possible to obtain a close adjustment of the bean opening, but it is also possible to make the adjustment without greatly disturbing the flow of the well. Too much disturbance of the flow while a test is in progress, and especially while changing the bean opening, will usually delay the flow conditions in the well reaching equilibrium and prolong the period of test.

Beans of the non-adjustable type have to be removed when a change of bean opening has to be made. For this reason, they are usually installed on the well in duplicate so that when a change in flow-bean opening is necessary, the flow can be instantly switched from one bean to the other. To obtain the exact opening desired may entail having a large number of beans of different size openings on hand.

Where very close control is desired it is good practice to use the adjustable type of bean. A change of bean opening is accomplished by the turn of a handle and the adjustment can be made as fine as desired.

A fuller utilization of the gas energy and a better flowing efficiency can often be obtained by the use of a bottom-hole choke. With the surface flow-bean the pressure at the tubing head and on the downstream side of the flow-bean is often excessively high, and very much greater than is at all necessary. The gas is at high pressure and is capable of doing more work. By the installation of a bottom-hole choke in the tubing it is possible to flow the well so that by the time the oil and gas reach the surface the pressure is at or near atmospheric pressure, or, if desired, at or near trap pressure.

One reason for the limited use of bottom-hole flow-beans has been the mechanical difficulties that have had to be faced.

Bottom-hole beans of the non-adjustable, non-removable type have been experimented with in wells for years. Regardless of how good the results obtained, however, they are generally found to be impracticable in every-day oil-producing operations. A change of flow-bean size necessitates pulling the tubing, and this one factor alone is a serious limitation. Paraffin or sand troubles in a well also militates against their use on account of clogging or cutting out.

With the development of removable bottom-hole chokes and adjustable bottom-hole flow beans within the last few years, the use of bottom-hole beaning as a method of pressure control in flowing wells is gradually coming into use. Their use at present is confined largely to the pressure control of gas wells, in which service they have been singularly successful. The theory underlying the use of bottom-hole chokes in flowing oil wells is sound.[11] A thorough understanding of the well conditions, however, is essential to their successful

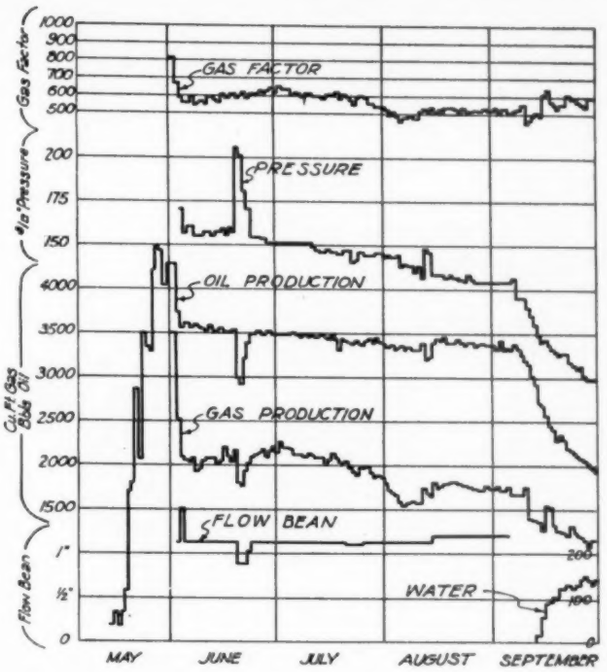

Fig. 5—An interesting record of a well produced under pressure control. Note the sudden drop in gas and oil production and pressure, and the increase in gas-oil ratio when water appeared in the well

use in practice.[12] We shall have occasion to discuss flow-beans, their construction and operation, in greater detail in a future article.

Wells vary in the thickness and position of their producing sands. In the Mid-Continent and in the fields of the eastern United States sands are relatively thin and continuous. In California and in some fields of the Gulf Coast the producing sands may be several thousand feet in thickness. These sands, instead of being continuous, are interbedded with bodies of shale and other unproductive strata. Some of the producing sands are so discontinuous that they can only be grouped into producing zones according to whether or not they are under the same pressure and have similar producing characteristics. In such cases, a well may be producing from several sands, each of which is under a different pressure and has a different gas-oil ratio. Producing such wells under proper pressure control must be based on a close study of the well conditions.[13] Production from the sands having a high gas-oil ratio must be restricted to a greater degree than the production from the sands with a low gas-oil ratio in order to utilize the gas energy to the best advantage in flowing the well.

In such cases, accurate and detailed records of the wells must be kept, including the daily production of oil and gas, the tubing and casing pressures at the well head, the gravity and character of the oil and gas, and flowing characteristics under different operating conditions. The pressure, the gas and oil content, and the physical character, thickness and depth of each producing sand penetrated is usually determined when the well is drilled. All such information is used in determining the proper rate at which to produce the well by pressure control.

It is obvious that when the output of wells of this type has to be curtailed, there is a wide choice of flow conditions that can be imposed on the well to make it produce at the desired rate.[14]

By varying the depth of the tubing in such wells it is possible to change the fluid level[15] and hence the pressure at the face of each producing sand. By intelligent adjustment of the tubing depth in the well and the flow-beans at the surface, flow conditions may be established that will maintain the desired pressure on the face of each producing sand.

The critical pressure that will result in a minimum gas-oil ratio for the well cannot be determined by any direct method or by any fixed rule. A high-pressure gas sand might be present in the well that it is not desired to produce. In that case an effort would be made to produce the well with as high a pressure on the face of the high-pressure gas sand as the rate of flow would permit. If this pressure were not enough to hold back all the high-pressure gas in the sand it would necessitate either reducing the rate of flow or producing the well with a high gas-oil ratio.

Another difficulty in the pressure control of flowing wells of this kind is the danger of loss into thief or barren sands. This condition has to be continually guarded against. It is a difficult problem, for as the well is produced the producing characteristics of each producing sand are undergoing a change. Seldom do any two producing sands become depleted, diminished in pressure, or undergo the same degree of change in flowing characteristics. How fast these changes occur in each producing sand as the well is produced depends upon the oil and gas content and the physical character of the formation of each producing sand.

Then there is the problem of water encroachment to be considered. A differential pressure between the well and the sand must be maintained that will hold the water in check as the well is produced.

These are among the most difficult problems in the whole domain of oil production and we shall have occasion to consider how these problems are attacked in the field. A mastery of some of the principles involved in the solution of such problems will aid in analyzing many of the more common difficulties met with in the field.

●

QUESTIONS

1. What is meant by Pressure Control as applied to an oil well?
2. What is the Gas-liquid ratio? The Natural gas-oil ratio?
3. What is a common source of error in making gas measurements at flowing wells?
4. What is the advantage of using an adjustable bean in flow tests?
5. What advantages are to be gained by bottom-hole choking? Explain.
6. What difficulties in applying pressure control are present in a well producing from several different sands?

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Elements of Applied Petroleum Refining » » » » » » »

Article III

TYPICAL FLOW DIAGRAMS AND OPERATING DATA

By W. L. NELSON
Professor of Petroleum Refining
University of Tulsa

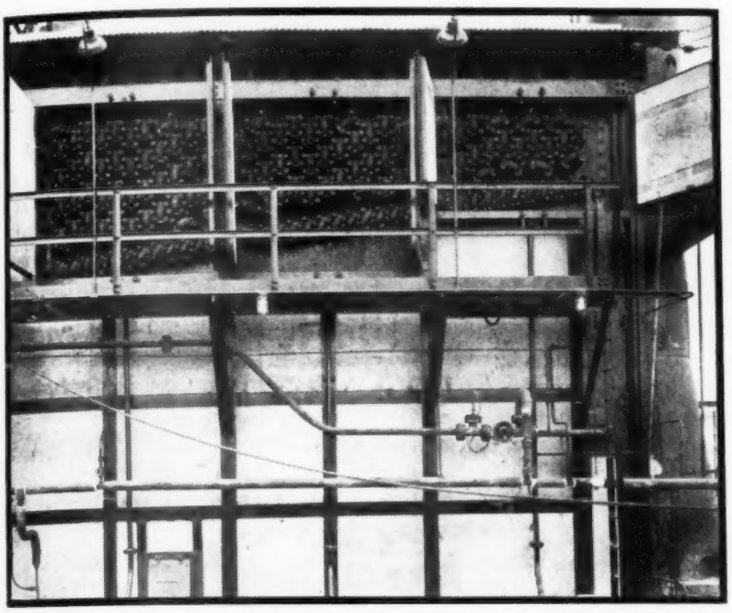


Fig. 8. Overhead connection type still (header boxes open)

Refinery Equipment

ALL petroleum distillation processes are fundamentally the same. In all these processes the charge stock must be heated, the mixture of vapors produced must be separated into products and the products must be condensed and cooled. If the engineer understands the uses and limitations of the various equipment that is available for these purposes he will be able to outline a logical flow diagram for a process or be able to pass judgment upon processes that may come to his attention. The various pieces of refinery equipment, such as pipestills, fractionating towers, condensers, coolers, and strippers, will be briefly discussed.

PIPESTILLS AND HEATERS. The pipe or tube still is the most commonly used heater. In many plants shell stills are still in use, but they are seldom installed in new plants. Tubular steam heaters are also used if the stock is to be heated to a relatively low temperature. Steam heaters are similar in construction to tubular condensers and heat exchangers. These will be discussed later.

Pipestills consist of seamless steel tubes, housed by refractory brick and supported on the outside of the still by structural steel. The tubes are connected to other tubes by return bends as indicated in the overhead convection type still. Fig. 8. Some of the tubes are in the combustion chamber and these tubes absorb heat by radiation from the flame and the hot walls. Other tubes, called the convection section, absorb heat from the hot flue gases as the gas travels around the tubes and out to the breeching and stack. Arrangements of these two sections, the radiant and the convection, are shown in the line diagrams, Fig. 9. Pipestills are generally grouped as radiant and convection types of stills, depending upon which section of the still absorbs the largest amount of the heat. Thus, stills (c), (d) and (b) can easily be built with a large amount of radiant surface and are classed as radiant type stills, while stills (f) and (e) absorb a large proportion of the heat by convection and are classed as convection type stills. A large proportion of radiant surface causes the rate of absorption (B.t.u. absorbed per sq. ft.) to be low while a small amount of radiant surface causes high absorption rates. Since the heating of oil, without producing coke in the tubes, is a difficult operation the radiant, mild-heating types of stills have been generally accepted, and stills of the type (f) are now rarely seen.

Another way of getting low absorption rates in the radiant section is by flue gas recirculation (e), Fig. 9. These stills have been used extensively in several cracking processes because the absorption of heat at high temperatures (850 to 950 deg. fahr.) is particularly conducive to the formation of coke. Recirculation stills are expensive and involve a continuous power expense, but the rate of heat absorption can be varied at will by changing the quantity of gas that is recirculated. Preheated air tends to increase the flame temperature and the intensity of radiation. Hence air preheat and recirculation act in opposite ways. Air preheaters are not used extensively in refineries.

FRACTIONATING TOWERS. During heating, whether in a pipestill or a shell still, a mixture of vapors results. The vapors and the unvaporized oil are admitted to the vaporizer section of the tower. Normally this section is situated about four plates from the bottom of the tower. The vaporizer section can be built just as any other tray except that the distance to the next tray above is at least 27 in., whereas the distance between regular trays is about 22 inches. The general features of a bubble-cap type of fractionating plate or tray are shown in Fig. 10. Liquid (reflux) flows from tray to tray through the downspouts. As it flows across the tray, the vapor passes through the bubble caps and through the liquid, promoting intimate mixing.

Separation of the vapors into products having a limited boiling range is accomplished by means of a cooling agent, reflux, which is pumped into the top of the tower. The cooling agent usually has the same composition as the overhead or lightest product produced from the tower. If any vapors, having a high boiling point, reach the top plate they are condensed by the relatively cool reflux. As they are condensed, heat is delivered to the reflux and a part of it is vaporized. Thus the entire vapor that leaves the top tray has the composition of the overhead product and the liquid overflowing to the plate below the top is no longer pure overhead

product because it contains the condensed high-boiling material. Each plate functions in this manner so that each plate has a liquid of different composition on it. As we descend the column the liquid consists of higher and higher boiling material and as we ascend the column the vapor consists of lower and lower boiling material. The lowest boiling product passes out of the top of the column (along with the reflux) as a vapor and the higher boiling products (such as kerosene and gas oil in a topping distillation) are drawn as liquids from different trays in the column.

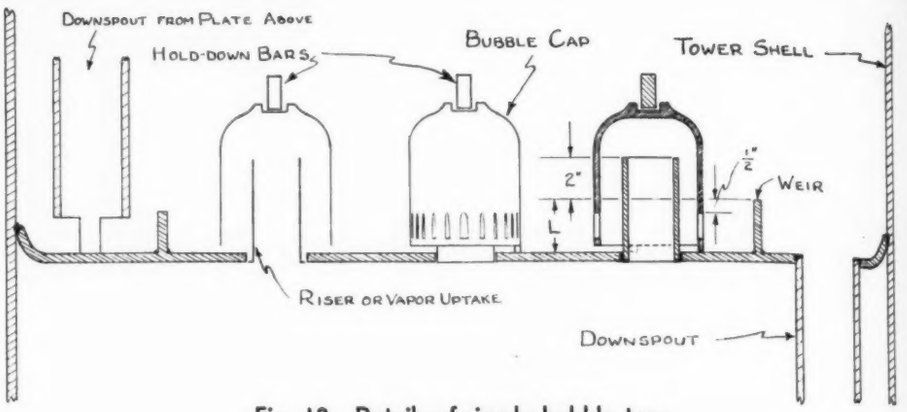


Fig. 10. Details of simple bubble tray

The plates below the feed plate or vaporizer are normally steam stripping plates and do not function as above, but they are constructed in the same manner. The function of these plates will be discussed under stripping.

VAPORIZERS. Frequently the hot oil from a pipestill is admitted to a vaporizer rather than into the vaporizer section of a bubble tower. The vaporizer is nothing more than a plate steel vessel in which the unvaporized oil accumulates, and the vaporized portion passes on as a vapor. In a sense it corresponds to the steam drum of a boiler. With a proper tower design the vaporizer can usually be dispensed with entirely. However, in certain operations, such as cracking, the hot oil vaporizes so violently that a part of the liquid residue may be carried as droplets in the vapor, and under such conditions a separate vaporizer outside the tower is advisable. The vaporizer should have enough capacity to accumulate liquid for a few minutes and thus act as a surge tank in case of erratic operation.

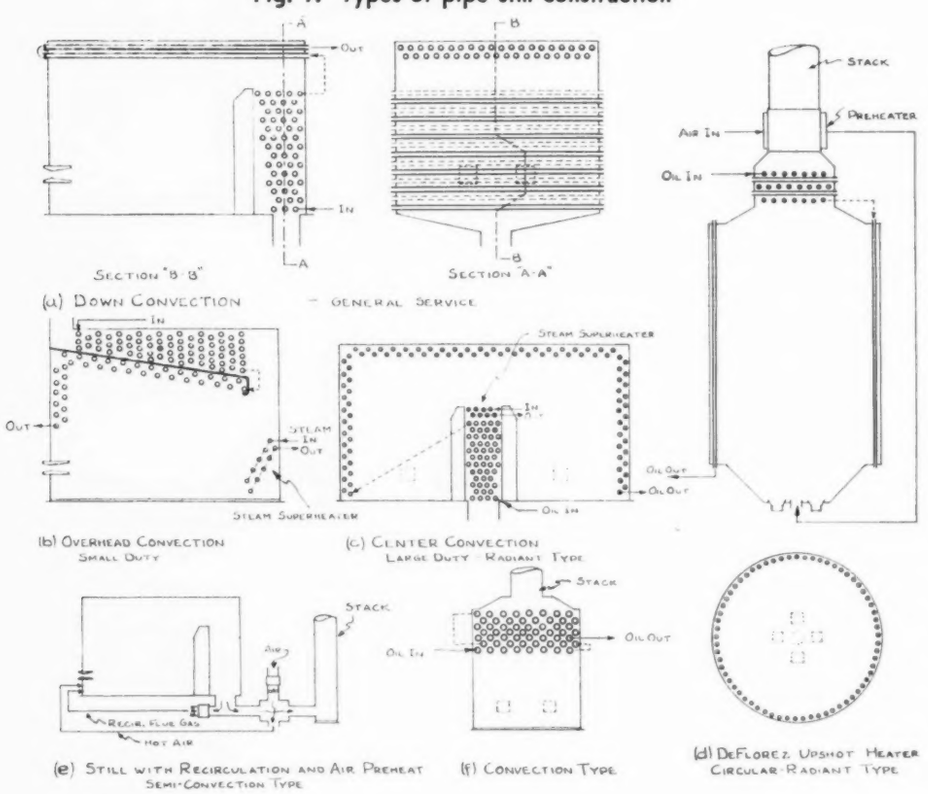
If the charge stock contains abnormal amounts of solid materials such as coke, sand, lime, rust, etc., a separate vaporizer is advisable.

STEAM STRIPPERS. The separation of side products from one another by a fractionating tower is not good because light vapor must pass the side-draw plates on their way to the top. Part of the light vapor is dissolved in the liquid side-draw products. In other words, the kerosene from a topping unit may contain a small amount of heavy gasoline and the gas oil may contain a little heavy kerosene and even a trace of gasoline. These contaminations are most economically removed by stripping with steam. In such an operation the oil flows down a small bubble tower and steam passes up through the tower. The steam causes part of the oil to be vaporized but the vaporized part is lighter than the original oil and contains most of the contamination. The steam and the part that is vaporized passes directly back into the main column above the drawoff plate.

A separate stripping column situated close to the main fractionating column is the usual arrangement, but certain manufacturers have installed the stripping plates within the main column (internal strippers).

The plates below the feed in the main column are stripping plates for the bottoms product. Steam bubbles up through these plates and into the vaporizer, carrying with it the "light-ends" that have been stripped from the bottoms product.

Fig. 9. Types of pipe still construction



CONDENSERS AND COOLERS. This equipment is built in two general types, coil-in-box and tubular. The cost of each of the two types is about the same, although the tubular type is less expensive when used under suitable conditions. The tubular type is not usually used if the cooling water is hard or if severe corrosive conditions exist.

Coil-in-box condensers and coolers consist of pipe connected together with bends in a series arrangement with the entire coil supported in a plate-steel water box. In condensers the volume of vapor is so large that several rows of tubes are manifolded together so that the vapor passes in parallel through the several rows. In coolers, however, the volume of liquid that is handled is much less and the tubes are connected in series throughout. The liquid traverses the top tubes, then the second layer down, etc., through the entire coil. Class C cast iron pipe with Class D fittings is considered as the best practice, but for mild conditions extra heavy pipe with malleable fittings is used.

Tubular condensers and coolers are constructed in much the same way as exchangers. Note Fig. 11. The shell is usually constructed of cast iron but for high-pressure service cast- or forged-steel shells are required. Steel or admiralty metal tubes are used, depending upon the corrosive conditions and the temperature. The vapor occupies so much volume that it is usually passed through the *shell-side* or outside the tubes, and the cooling water is passed through the tubes or the *tube-side*.

The amount of heat transferred per sq. ft. of surface is much greater in the tubular equipment because of the greater velocity of the fluids, but the cost per sq. ft. is higher, with the result that the total cost is about equal for the two types.

HEAT EXCHANGERS. Exchangers are used to recover some of the heat that is contained in the products from the fractionating tower. They are similar to tubular coolers but the charge stock is used as a cooling medium rather than water. The general construction is indicated in Fig. 11.

The amount of heat that is transferred from the product to the charge stock is dependent on several factors. The most important of these are (1) the temperatures of the two stocks, (2) the velocities of the two fluids past the heating surface, and (3) the viscosities of the two stocks. Obviously, the larger the difference in temperature of the two stocks the more rapid the transfer of heat. Likewise, high velocities and low-viscosity fluids tend to permit the transfer of more heat.

The hot product from the fractionating tower is usually at a low pressure and hence it is usually passed through the shell-side of the exchanger.

OTHER EQUIPMENT. All the aforementioned equipment is most important for an understanding of distillation processing, but many other pieces of equipment are used. Pumps, with which to handle the various liquids, are necessary. If gas is produced, gas separators are necessary. The reflux used in fractionating towers is usually handled with a centrifugal pump and hence a reflux accumulator is usually necessary in order to provide a suction head for the centrifugal pump. If a solid material, such as coke, is produced, a vessel for the accumulation of the solid such as coke-drums, settlers, etc., may be required.

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QUESTIONS

1. Name three types of equipment that are used for heating oil.
2. How can a mild or low rate of absorption be obtained in the radiant section of a pipestill?
3. Distinguish between tubular condensers, heat exchangers and steam heaters.
4. Why must side-draw products from a fractionating tower be stripped with steam?
5. Under what conditions are tubular condensers and coolers unsatisfactory?
6. Compare the temperatures on various plates of fractionating column. Compare likewise the composition of the liquid on each plate.
7. What is the composition of the reflux relative to the composition of the products from the column?
8. What three factors are most important in governing the rate of heat-transfer in a heat exchanger?

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The details of the design of this equipment is not presented completely in any single reference. By far the best method of learning about refining equipment is by studying the trade bulletins of manufacturing companies or by examining blueprints of installations.

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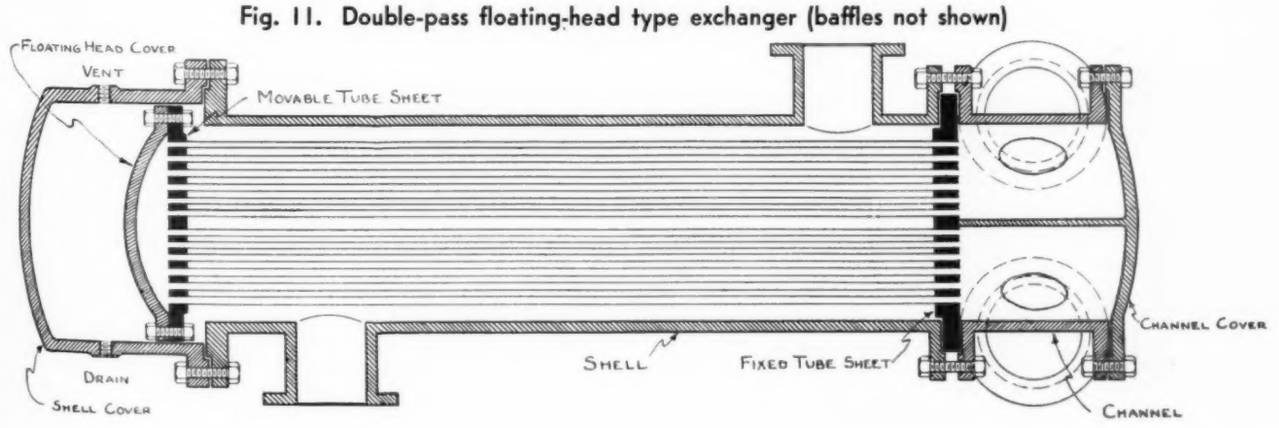
Fig. 11. Double-pass floating-head type exchanger (baffles not shown)



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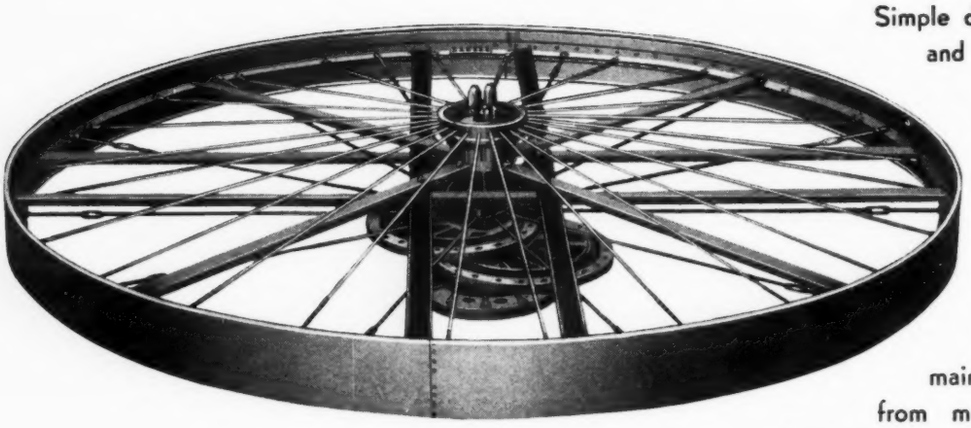

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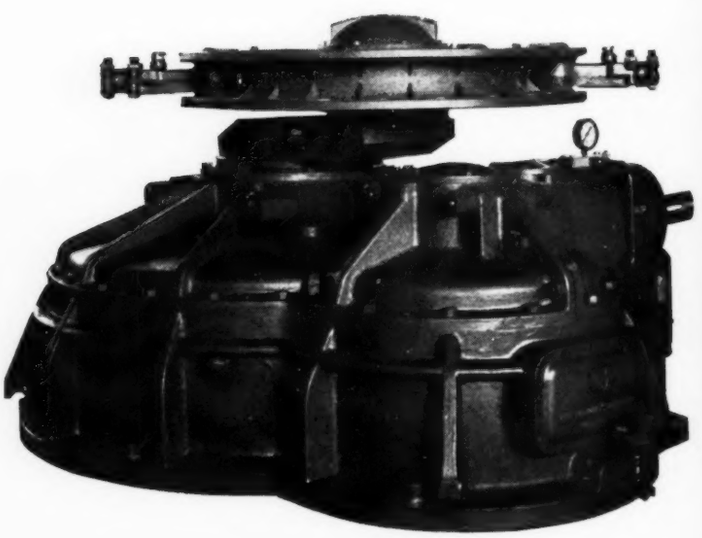

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Vocational Refinery Mathematics

Article III

PUMPS

Calculation of Efficiencies, Head, Horsepower and Other Factors

« By P. ALBERT WASHER »

PUMPS may be classified in various ways, but for consideration of their mechanical action they may be best considered under the following heads:

1. Displacement Pumps.
   a. Reciprocating.
   b. Rotary.
   c. Air Displacement.
   d. Continuous flow.
2. Impeller.
   a. Centrifugal.
   b. Jet.
3. Impulse.
4. Bucket.

Displacement pumps are those in which the liquid is induced to flow from the source of supply through the inlet pipe, through the inlet valve and into the pump chamber by the vacuum created by the withdrawal of some physical agency, which, on its return, displaces a certain volume of the liquid contained in the chamber and forces it to flow through the discharge valves and discharge pipes.

The methods of computing the various data for the direct-acting steam pumps are outlined below.

Displacement. The displacement of a single double-acting pump can be calculated theoretically by the formula:

(34) $D = (A \times T \times 12)/231 = .0408\ d^2\ T$

in which:

D = Displacement of double-acting plunger, U. S. gal. per minute.
A = Area of piston or plunger in sq. inches.
d = Diameter of piston or plunger.
T = Piston travel in ft. per minute.

To find the diameter of the water piston or plunger to give a specified displacement, we may use:

(35) $d = 4.95 \sqrt{D/T}$

in which:

d = Diameter of the piston or plunger.
D = Displacement in U. S. gal. per minute.
T = Piston travel in ft. per minute.

Example: To find the diameter of a pump piston to handle 800 gal. per min. at 75-ft. piston travel:

$d = 4.95 \sqrt{600/75} = 14$ in.

There is a loss of capacity in the operation of a pump due to leaky valves, piston packing, stuffing boxes, or suction head. This loss is generally stated as percentage of the displacement and is called slip.

(36) $S = L/D$

in which:

S = Slip.
L = Loss by leakage in gal. per minute.
D = Displacement in gal. per minute.

Slip varies from 2 to 10 per cent, depending on the condition of the pump. Five per cent is often used in estimation.

Capacity. The capacity of a pump is the actual volume delivered, and equals displacement minus slip.

(37) $C = D - S$

in which:

C = Capacity in U. S. gal. of 231 cu. in. per minute.
D = Displacement in gal. per minute.
S = Slip in gal. per minute.

Volumetric Efficiency. The volumetric efficiency of a pump is the ratio of capacity to displacement, and equals:

(38) $E_v = C/D.$

Hydraulic Efficiency. The hydraulic efficiency is the ratio of the total head pumped against to the total head pumped against plus the hydraulic losses.

(39) $E_{hy} = H/(H+L).$

Hydraulic losses consist of frictional losses in the suction pipe, pump valves and seats, as well as the velocity head.

Mechanical Efficiency. The ratio of the indicated horsepower of the water end to indicated horsepower of the steam end is the mechanical efficiency and equals:

(40) $Em = HPw/HPs.$

This varies from 50 to 90 per cent and can be determined only by actual test.

Steam Indicated Horsepower. Steam i.hp. is calculated by the following formula:

(41) i.hp. = PLAN/33,000

in which:

L = Length of stroke in feet.
A = Area of steam piston in sq. inches.
N = Number of strokes per minute.
P = Industrial m.e.p. (mean effective pressure) in lb. per sq. inch.

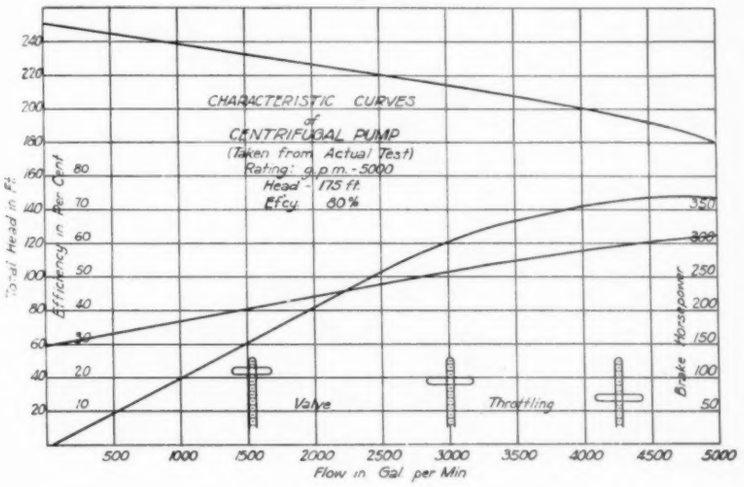
This formula is one of the most important in the group.

The Centrifugal Pump. The most important type of the second great class of pumps is the centrifugal. In this pump, the energy is applied to the liquid by means of pressure due to the velocity of a mechanical agency.

To the average refinery worker the most important item as far as the centrifugal pump is concerned is the computation of the total head. Not only is this important in ordering a pump, but it is absolutely necessary for checking the water horsepower and the efficiency of the pump. The total head against which a centrifugal pump operates is made up of the sum of the following factors:

1. *Friction Head*—This consists of pressure drop in the

Fig. 1



line caused by valves, bends, skin friction, etc. It is calculated by the Fanning Formula (Equation 33).

2. *Suction Lift*—The suction lift is the vertical distance from the head of the water to be pumped to the center line of the pump. If water level is above center line this distance is subtracted from the sum of the remaining factors.

It should be remembered that the pressure head available to create suction is modified by the temperature of the liquid pumped and by gases reaching the pump either with the liquid or by air leakage in the suction pipe.

3. *Velocity Head*—

(42) $H = V^2/64.4$

in which:

$V = (.408 \times \text{gal./min.})/D^2$

D = Dia. of pipe in inches.

4. *Elevation Difference*—This is obtained simply by adding or subtracting elevation of pump from elevation of delivery point. Add or subtract factors accordingly.

5. *Residual Pressure*—The delivery pressure desired.

Next to knowing how to calculate the total head the operator is most anxious to check the efficiency of his pump. The efficiency of any centrifugal pump is equal to:

(43) E = (Water hp./brake hp.) $\times$ 100

E = Efficiency in per cent.

(44) Water hp. = (8.34 $\times$ g.p.m. $\times$ head in ft.)/33,000.

(45) Brake hp. = Volts $\times$ amp. $\times$ cosΦ $\times \sqrt{N} \times$ M/746

where:

M = Motor efficiency. (80 to 94 per cent, depending on conditions)

N = No. of phases.

CosΦ = Power factor of motor, watts/(volts $\times$ amp.), assume 9 to 1.

Example of use of the above formulae:

Figure the theoretical horsepower required to transmit 1000 bbl. of oil per hour under the conditions imposed in the problem on pressure drop in the previous article. Use brake hp. as 80 and 180 respectively (obtained from equation 47).

Part 1:

$(1 \times 42 \times 152 \times 144 \times 1000)/(60 \times 7.48 \times 33{,}000) =$ 62 hp.

Therefore: $E = 62/80 = 77.5$ per cent.

Part 2:

$(2 \times 42 \times 315 \times 144 \times 1000)/(60 \times 7.48 \times 33{,}000) =$ 128 hp.

Therefore: $E = 128/180 = 71.2$ per cent. (using motor efficiency of 87 per cent).

The following data on centrifugal pumps are reviewed briefly.

The speed of a centrifugal pump is calculated as follows:

(46) If D = diameter of impeller in inches, and

N = r.p.m.

then: $(D \times 3.1416 \times N)/(12 \times 60) = 9.6\sqrt{H}$

and $N = 2200 \sqrt{H}/D$.

Changes in speed involve changes in horsepower necessary for operation and in resulting head and discharge of the pump.

	Easy Way to Remember
(47) Capacity varies directly as the speed	C varies as S^1
(48) Head varies directly as the square of the speed	H varies as S^2
(49) Hp. varies as the cube of the speed	P varies as S^3

(50) Efficiency remains practically constant.

Example: Pump operating at 1125 r.p.m. Suppose speed is increased to 1440 r.p.m. (500 g.p.m., 150-ft. head, 79 per cent eff., 24 hp.). What will be the new conditions?

Solution: Ratio of new speed to old:

$1440/1125 = 1.28$.

a. $1.28 \times 500 = 640$ g.p.m. at 1440.

b. $1.28^2 \times 150 = 246$-ft. head at 1440.

c. $1.28^3 \times 24 = 50$ hp. at 1440.

d. 79 per cent eff. (practically the same).

When the speed of a centrifugal pump is fixed and a change is desired in quantity of discharge and in the head, this may be accomplished, where the design of the pump will permit, by a change in diameter of the impeller. Such will involve a change in the horsepower for its operation and in the resulting head and discharge of the pump as follows:

(52) C varies as D

(53) H varies as D^2

(54) P varies as D^3

Where vertical centrifugals are used for water supply:

(55) Be = (g.p.m. $\times$ hd. in ft. $\times$ 8.34 $\times$ 100)/[33,000 $\times$ (b.hp. — losses in shafting, bearings, etc.)]

where:

Be = Bowl efficiency in per cent.

(56) $Hd = K + S_1 + I_1$ where:

Hd = Hydraulic downthrust in pounds.

K = Constant worked out for different pumps.

S_1 = Shafting weight in pounds.

I_1 = Impeller weight in pounds.

Statements that invariably provoke discussion under the subject of centrifugal pumps are well worth mentioning.

1. The pressures of centrifugal pumps in series are additive; or, a centrifugal pump takes whatever pressure is delivered to its suction and adds it to what it makes. If it makes 100 lb. and the suction pressure is 100 lb. the total pressure is 200 lb. per sq. inch.

2. Regardless of the specific gravity of the liquid, a centrifugal pump will always produce the same static head.

3. Throttling or pinching the discharge will increase the power consumption per thousand gallons pumped.

Statement No. 1 was proved by using formulae from Physics. To satisfy a few "doubting Thomases," however, an actual demonstration was made, using two centrifugal pumps. One of these was good for a total head of 150 ft., while the other was good for 300 feet.

Statement No. 2 necessitated several different examples to make it stick. One of these is given:

"Suppose a pump is required to elevate brine of 1.2 sp. gr. to a static head of 100 feet. Any pump suitable for lifting water will also lift brine to the same height. The pressure gauge will register the weight of a column of brine 100 ft. high. A column of water 100 ft. high would show 43 lb. pressure. As brine is 1.2 times heavier than water the gauge will show: 43.1×1.2, or 52 lb. pressure.

Statement No. 3 proved to be an interesting method of acquainting each member with the characteristic curves and their significance. A typical set of curves were calculated by the formulae given in this article and plotted on graph paper as shown in Fig. 1. The situation can easily be visualized by drawing a valve being throttled. To bring out clearly the meaning of throttling certain points were selected from the characteristic curves and tabulated as follows:

Flow in gal./min.	5000	4000	3000
Head in ft.	180	200	213
Efficiency	74	71	59
B. hp.	310	287	255
Cost, dollars per day (assume 1c/kw. hr.	61.60	56.70	50.60
Cost, cents per 1000 gal.	0.85	0.99	1.17

Motor eff. of .9 used in calculations.

This procedure quickly revealed to the average man the expediency of using the proper capacity pump for the occasion. Thus, instead of operating a 5000-g.p.m. pump when the flow was only 3500 g.p.m. he realized the most economical procedure was switching over to the pump of smallest capacity, that is, the 4000-g.p.m. pump.

Check

THESE FEATURES OF ELECTRIC WELD PIPE

against any other pipe

- 100% WELD ✓
- LONG LENGTHS ✓
- PERFECTLY ROUND ✓
- CLEAN INSIDE AND OUT ✓
- UNIFORM WALL THICKNESS ✓
- STRAIGHTNESS ✓
- FINE FOR EVERY TYPE OF JOINT ✓
- ANY DEGREE OF STRENGTH OR DUCTILITY ✓

Do this and you can't go wrong, whether it's casing or tubing you need for a well, pipe for a long line, or a pipe for the building of a new refinery or the maintenance of an old one.

Certainly most pipe has a dependable weld, but Republic Electric Weld is 100 per cent. Some pipe can be had in long lengths—Electric Weld is made up to 50 feet. And as you check the features of this better pipe you will find that while other makes possess some of them, only Republic Electric Weld can honestly claim to have them all.

And it's all in the way it's made. Clean strip is formed cold to a perfect round. The seam is welded by electrical resistance where the edges meet. No metal is added at the weld and the grain structure is virtually the same at the weld as at any other point in the pipe wall. No furnaces to cause scaling. No heating of the entire mass of metal to make it out of round. No long cooling to jeopardize its straightness.

Before you buy pipe check into the advantages that Republic Electric Weld Pipe will bring to your particular work—find out how it will save you time and money. Write for a copy of "Electric Weld Pipe." A reading is convincing.

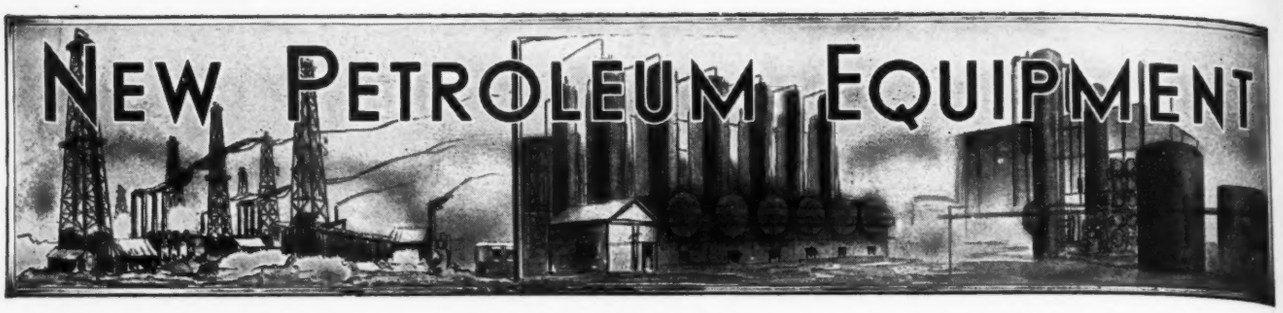
REPUBLIC STEEL CORPORATION

GENERAL OFFICES YOUNGSTOWN, OHIO

REPUBLIC

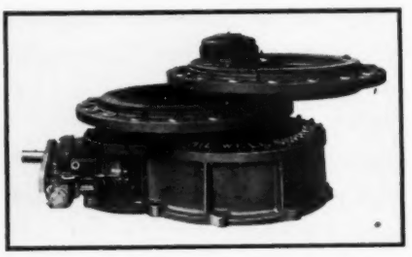
ELECTRIC WELD

LINE PIPE • CASING • TUBING



Oilbath Geared Power

THE OIL WELL SUPPLY COMPANY of Dallas, Texas, recently added the Imperial No. 50 to its line of Oilbath Geared Powers. It is of the stationary spindle design and is similar in construction to the Imperial No. 80 (eccentric-type). It is smaller than the No. 80, however, and is rated 50 hp. at



20 s.p.m. for oil field service. This is a very conservative rating since its industrial capacity (Lewis formula) is 172 hp. at 20 strokes per minute.

The double reduction gears are of the silent helical type and are fully heat-treated to provide the best wear characteristics and assure long life. The main gear and eccentrics revolve as a unit around the stationary spindle which is an integral part of the strong semi-steel base. Extra-large bronze bushings carry the radial load of the main gear and eccentrics. A heavy-duty ball thrust bearing supports the weight of the main gear and eccentrics. The high-speed and intermediate speed shafts are mounted in heavy-duty Timken tapered roller bearings.

The base and cover form an oiltight and weatherproof enclosure for the gears and bearings which are lubricated by a combination oilbath and positive forced-feed circulation system. The oil pump is mounted on the outside of the gear case where its operation is readily inspected. It forces oil to all the wearing parts through individual oil lines by means of separate plungers, thus assuring lubrication at all times. The oil pump is driven by a short chain drive from the high-speed shaft.

The Imperial No. 50 Oilbath Geared Power is equipped with either one or two eccentrics which are regularly furnished for a 24-in. or 30-in. stroke. The eccentric straps are of large cross-section, lined with babbit and provided with forced-feed lubrication. The wearing surfaces are protected from the intrusion of foreign matter. Each eccentric strap is provided with 18 clevis holes which are protected from wear by replaceable hardened-steel bushings. The clevis pins are drilled for Alemite lubrication.

The overall reduction ratio, 27.8:1, is very satisfactory with any type of prime mover ordinarily used in the oil fields. Sturdy and compact construction and minimum height of the pull-rod connections above the foundation are some of the outstanding features of this Power. It is offered as an efficient and dependable unit for all central power installations within the limits of its capacity and is especially recommended for pumping a large number of shallow wells.

Wiper for Lufkin Cagers Tapes

TAPE WIPER No. 599 is announced by the Lufkin Rule Co. It is a sturdy and compact attachment, fitting all Lufkin Oil Gagers Tapes, and wipes the oil from the line as it is wound on reel. Such a tape attachment has long been needed, and the Lufkin Wiper will no doubt serve the purpose well, for, the manufacturers state, it has been designed with the aid of suggestions from

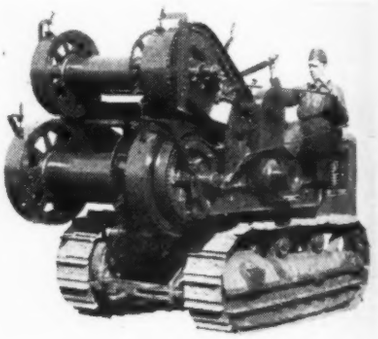
practical oil men in the various fields and has been thoroughly tried out.

The tension of the Wiper pads is easily regulated by thumb screw, which screw is headed so it cannot become lost. With it the tape line can also be held at any point. The pads are easily replaced, and six extra ones are packed with each Wiper.

Position in which wiper is placed on tape frame is shown above. It can be so assembled in the field on old tapes, and when wanted on new tapes it is necessary only to specify "with wiper" and they will be supplied so assembled.

Oil Field Servicing Winch

THE ALLSTEEL Products Manufacturing Company, Wichita, Kansas, has designed a double-drum field servicing winch for mounting on Caterpillar Thirty-Five Diesel or gasoline-



powered wide gauge or standard tractor. These units, known as type HB-35, like all Allsteel units, are equipped with the company's patented wedge-action brakes, alloy brake flanges and Timken bearing drums. An important feature is that the parts in both drum assemblies are standard.

The HB-35 lower drum has a capacity for 7400 ft. of 9/16-in. line; the upper drum has a capacity for 4300 ft. of 9/16-in. line, and is the correct size for wells up to 4000 ft. in depth. The weight of this unit, exclusive of the tractor, is only 5400 pounds.

These double-drum winches are built in two larger sizes—for the Caterpillar Fifty and the Caterpillar Seventy-five tractors, as well as for Allsteel HS, KS and MS series skid winches, thereby furnishing a size double-drum unit for any depth well.

WHAT'S BACK OF WIRE ROPE IS VITAL

SPECIAL LINES FOR ANY JOB

NOTHING can replace experience in the drilling of a well. And—only experience can produce Wire Lines that most efficiently and economically meet every requirement of the driller. It is this background of wire making experience—over 100 years of it—that causes a great majority of operators to turn to the American Steel & Wire Company for lines of special size, construction and grade—lines to meet specific and unusual conditions. Whatever your need, ordinary or special, whether it be Cable Tool or Rotary Drilling Lines—or for Bailing, Sucker Rods, Tubing, Casing or Pumping Lines—here you will find unequalled quality and the most helpful type of engineering service.

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STEEL & WIRE COMPANY
WIRE LINES

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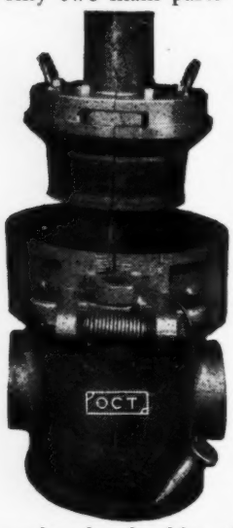
Blowout Preventer

OIL CENTER TOOL COMPANY'S improved blowout preventer has only two main parts when assembled; the main body, which is on the casing during the entire drilling job, and the packing unit, which latches around the drill pipe if gas pressure threatens. With a slight lowering of drill pipe after the packing unit has been latched around it, the steel shoulder of the packing unit clamps under the shoulder of the main body eccentric band. The tension spring, shown here, pulls eccentric band tight after the packing unit enters the preventer body.



The higher the pressure, the tighter the seal effected by rubber packing expanding against the preventer body.

This new O-C-T preventer is made of cast chrome nickel steel up to and including 5000 lb. test.

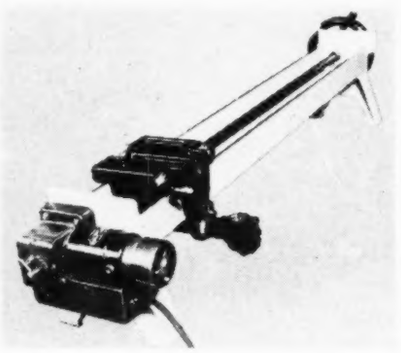
Complete description is given in the company's 1934 catalog.

Oxweld Straight-Line Cutting Machine

A NEW CUTTING MACHINE, known as the Oxweld Straight-Line Cutting Machine, has been added to the Oxweld line of welding and cutting apparatus by The Linde Air Products Company, 30 East 42nd Street, New York.

This machine consists essentially of a steel channel supporting base, a means for moving the blowpipe, and adjustments for setting the blowpipe to cut bevels. Motion in two directions is possible: 45 in. longitudinally and 7¾ in. laterally. The machine can be furnished either with two traverse hand-wheels for hand operation, or with one hand-wheel and a 110-115-volt universal motor, either of which can be used by simply throwing a lever.

The carriage is supported by a three-point suspension and an automatic



catch disengages the carriage from the worm drive when the end of the track is reached. The working parts are completely protected from dirt by a metal cover assuring trouble-free operation. The machine has a linear speed range of up to about 33 in. per min., depending on the gear ratio specified when ordering; and has a governor graduated in inches per minute for setting the speed. A reverse switch permits motion in either direction. A straight, steady cut is assured by roller springs that keep the gears in mesh and the carriage steady. The machine is light enough to be readily portable, but bolt-holes are provided for fastening it to a permanent support if this is desired.

The manufacturer states that, for the shop requiring a cutting machine for trimming or beveling plate, this machine is ideal, clean, finished cuts being made with greater accuracy and greater speed than can be made by hand; and in shops where straight-line cutting is a regular operation, the time and waste saved by a machine like this soon pays for it.

Cut and Pull Tool

J. S. Abercrombie Company, Houston, Texas, has improved the original Cut and Pull Tool which was recently acquired by this company from Charles R. Edwards and Houston Engineers, Inc., as an addition to Abercrombie's Red Ball Cutting Service in United States fields. Sales of the tool in foreign fields has been retained by the former owners.

The combination Cut and Pull Tool cuts and pulls the string of pipe on the same trip, as an inside cutting job, thereby eliminating many round trips. The cutting blades, operated by positive control, are driven out and withdrawn by a reliable method. Means are provided for centering and aligning the tool with the "fish" and for rotating and washing down to remove sand or shales from the "fish." If desired, the spear can be engaged before the cut is made so as to sustain the weight of the casing about to be cut off, thereby relieving cutters of danger of breakage.

The improved tool gives notice to the operator when the cut is completed, due to relieved strain of cutters and resulting in a change in pump pressure that has been driving the cutters.

The pulling device, an integral part of the combination tool, releases or engages the casing by a quarter turn of the drill pipe and a slight movement (down to release and up to engage the casing). A new cut can be made simply by moving up or down to a new position. All the cuts made can be pulled out of the hole.

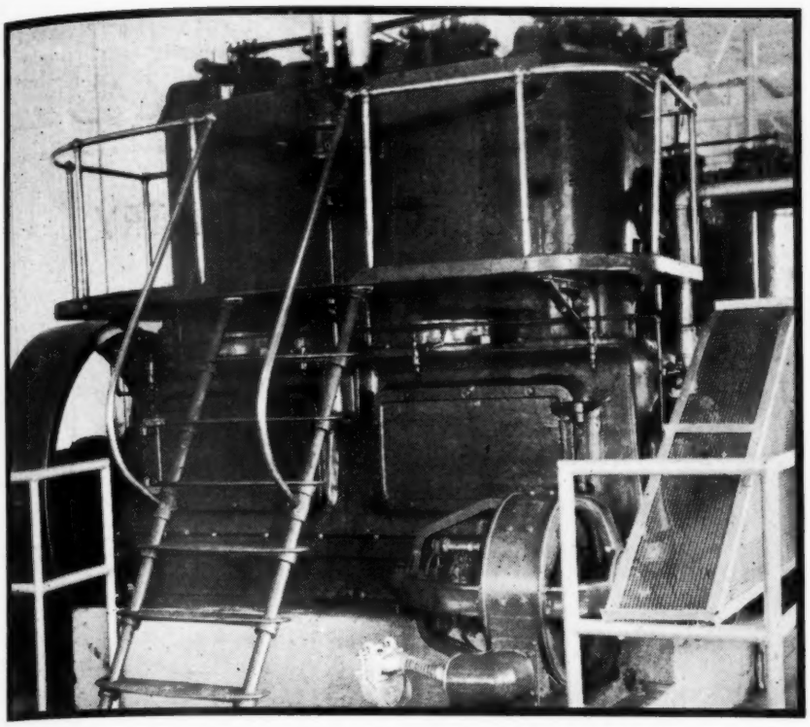
All the cuts of the tool are performed without a trip out of the hole, since there are no triggers or trips employed to require hand resetting after a casing hold has been made.

Acquisition of this tool, and improvements made, give J. S. Abercrombie Company a total of seven patents on pipe cutting and recovering tools, and other patents are still pending.

Safety Coupler and Crosshead

LUFKIN FOUNDRY & MACHINE COMPANY, Lufkin, Texas, has placed on the market a practical safety device for use in conjunction with central pumping. It is a safety coupler and crosshead that has simple, positive operation with no chance for injuring workmen when throwing wells off and on.

To throw off the well, simply raise weighted lever "A." To put the well on the pump simply throw lever "B" forward. The pipe cylinder is bored and a piston is fastened to power connection to which is arranged an automatic hook to pick up or release the rod line. The cylinder is dust-proof and contains sufficient oil for splash lubrication.



Double-duty gas engine prime mover at Phillips Pipe Line Company station. Flywheel end drives, through gear increaser, a centrifugal pump. Generator, shown to the right, supplies current for auxiliaries

A Gas Engine-Powered Crude Oil Pipe Line Station

By WARREN L. BAKER

THE first installations of gas engines as prime movers for driving high-speed pipe line pumps were made by the Phillips Pipe Line Company when it built its gasoline carrier from the Texas Panhandle to St. Louis, Mo., in 1930, and now this company has adopted the gas engine for service on its latest crude oil transportation system.

The use of relatively slow-speed engines to operate centrifugal pumps through step-up gears has been a marked trend in pipe line construction work, and the adoption of this method by the Phillips Company on the newest addition to its crude oil carrier system is another advancement in bringing about their wider usage.

Last spring, Phillips Pipe Line Company completed a 210-mile 8-in. pipe line from the Oklahoma City field north to Thrall, Kan., where it tied into the company's existing line to its Kansas City, Kan., refinery. Two stations on this line have been equipped with gas engines as prime movers for the pumps.

The company's Oklahoma station, located on the northeastern outskirts of the Oklahoma City field, consists of five gas-driven units and two electrically operated pumps. The gas engines are 165-hp. Bruce MacBeth units that operate at 250 revolutions per minute. Between the engine shaft and the Farrell gear increasers a Fast flexible coupling is being used, while a similar make of coupling is being used between the gear increasers and the Goulds centrifugal pumps.

Several interesting features developed in connection with coupling the engines to the pumps through gear increasers when the company constructed its gasoline line. Tests revealed that the pumps tended to run at uniform velocities while the gas engines operated at non-uniform rotations. Consequently, it was necessary that steps be taken to prevent shaft breakage. To remedy this a type of flexible coupling was installed between the engines and the gears that would not only compensate for a small amount of misalignment, but would, through resilient elements, take up the non-uniform rotation of the engines and prevent such rotations from reaching the pumps. The coupling used between the gear increasers and the pumps was designed to compensate for misalignment without setting up whip or crank action. The same type of coupling is being used in the Oklahoma station, and, as on the gasoline line, proving very satisfactorily.

The engines are operated on residue gas obtained from some of the Phillips Petroleum Company's gasoline plants in the Oklahoma City field. The fuel is introduced into the prime movers while passing through low-pressure regulators.

The engines are of the open jacket water type. Water for cooling purposes is procured from the production company's water system, from which source it is piped to a water tower. The water flows by gravity from the tower to the engines and then to turbine pumps that return it to the water tower.

Two of the gas engines are equipped so that they are connected to generators at one end and to the pipe line pumps at the other. These are used for generating electric current for operating the small auxiliary units. They are connected to the engines by V-belt drives.

The station has handled a peak load of 71,000 bbl. of crude oil per day, but now with a lower allowable being given the Oklahoma City field, its daily throughput is much lower.

The Oklahoma station is located at the junction of two lines, the 8-in. line to Thrall and a similar line running to Seminole, Oklahoma. It has a manifold of model design, which permits any pump to discharge into either line.

STRANGE.... *but* TRUE

HAPPENINGS IN THE PETROLEUM INDUSTRY

East Texas is the most prolific oil area ever discovered and therefore has established many interesting records.
A few of these are illustrated on this page....

Total Combined Production of the United States (nine states) during first 30 years of Industry's history was 405,000,000 barrels.

•

One field, East Texas, has produced 428,000,000 barrels in 3½ years..

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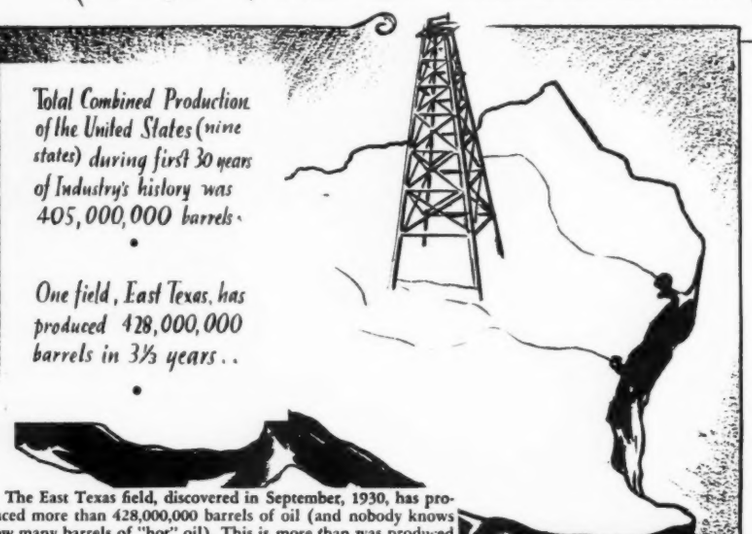
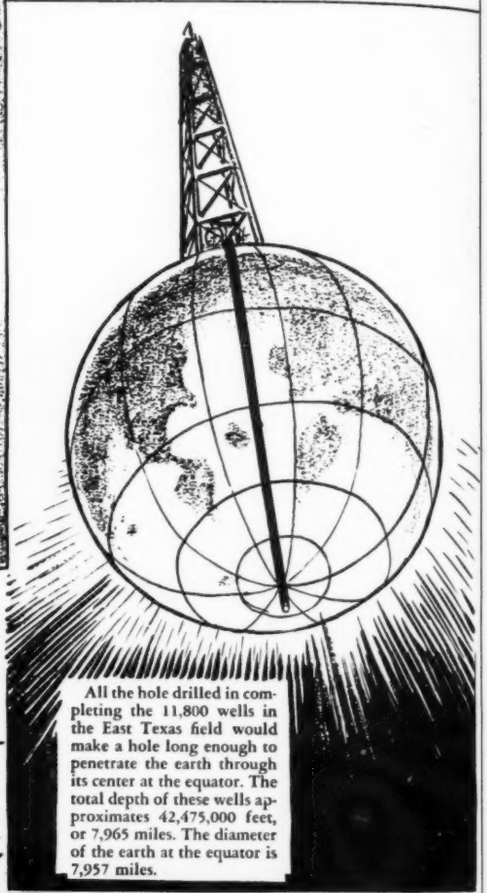
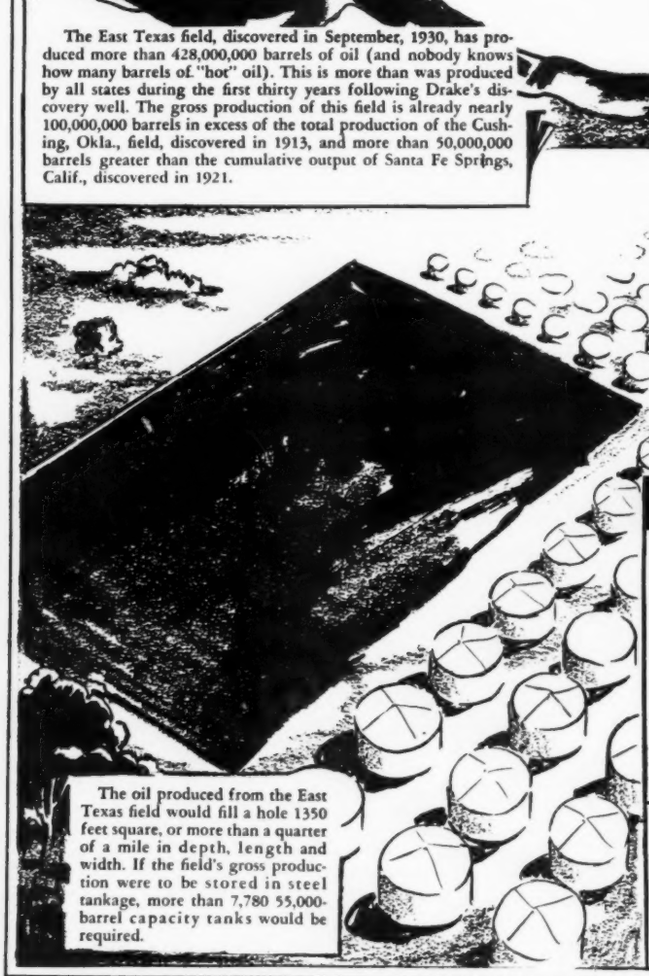


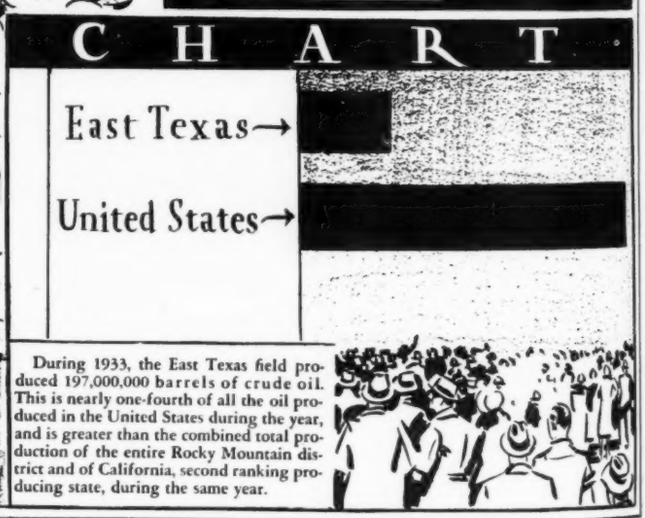
The East Texas field, discovered in September, 1930, has produced more than 428,000,000 barrels of oil (and nobody knows how many barrels of "hot" oil). This is more than was produced by all states during the first thirty years following Drake's discovery well. The gross production of this field is already nearly 100,000,000 barrels in excess of the total production of the Cushing, Okla., field, discovered in 1913, and more than 50,000,000 barrels greater than the cumulative output of Santa Fe Springs, Calif., discovered in 1921.



All the hole drilled in completing the 11,800 wells in the East Texas field would make a hole long enough to penetrate the earth through its center at the equator. The total depth of these wells approximates 42,475,000 feet, or 7,965 miles. The diameter of the earth at the equator is 7,957 miles.



The oil produced from the East Texas field would fill a hole 1350 feet square, or more than a quarter of a mile in depth, length and width. If the field's gross production were to be stored in steel tankage, more than 7,780 55,000-barrel capacity tanks would be required.



During 1933, the East Texas field produced 197,000,000 barrels of crude oil. This is nearly one-fourth of all the oil produced in the United States during the year, and is greater than the combined total production of the entire Rocky Mountain district and of California, second ranking producing state, during the same year.

Oil Fields of Mexico Depicted in New Educational Motion Picture Film

An interesting and instructive mental journey "Through the Oil Fields of Mexico" is afforded in a new three-reel "silent" educational motion picture film, bearing that title, prepared under the supervision of the United States Bureau of Mines in coöperation with an oil producing company. The film comprises the latest addition to the Bureau's comprehensive library of films visualizing the mineral and allied industries.

A story of the Mexican oil industry would be incomplete without portraying the customs of its peoples, the many interesting and beautiful scenic wonders of the country, and the many interesting episodes incidental to the bringing in of numerous world-renowned oil wells.

The first part of this picture, Reel No. 1, offers general views around the oil fields of Mexico, including Cerro la Pez (Hill of Har), with its numerous oil seepages; Cerro la Dicha, one of the richest areas in Mexico; Cerro Azul camp, with its camp life, and also shows two of the world's best-known oil wells—Potrero del Llano and Dos Bocas—especially uncontrolled flow of oil from the first of these, which continued for about three months, although part of it was saved by a dam built across a river.

Reel No. 2 pictures a modern camp with beautiful surroundings at Cpapapote Nunez, close to Tuxpam River and near one of Mexico's richest oil pools; results of fire which burned three months at Dos Bocas well; oil gushing in great volume from one of several large "spouters" brought in, and the catapulting of tools through top of derrick; a gas-absorption plant and pump station, illustrating type of equipment used in Mexico; laying a pipe line; a tank farm where crude and refined products are stored; and a refinery.

Reel No. 3 shows the shipping of petroleum products by tank car from Vera Cruz to Mexico City and en route the beautiful snow-capped summit of Orizaba, monarch of the Mexican peaks, over 18,000 ft. high; street scenes in Mexico City and in Tampico, second largest oil port in the world; and a tanker with cargo of oil leaving Tampico and arriving at Baltimore; where it is gaged, tested, and pumped by hose into pipe line connected with shore tanks.

Copies of this film, "Through Oil Fields of Mexico," in both the 16 millimeter and 35 millimeter size, may be obtained for exhibition by educational institutions, engineering societies, churches, clubs, civic and business organizations and others upon application to the United States Bureau of Mines, Experiment Station, 4800 Forbes Street, Pittsburgh, Pa. No charge is made for the use of this film, although the exhibitor is required to pay all transportation charges.

Lion Oil to Install New Refinery Equipment

Lion Oil Refining Company, of El Dorado, Ark., has entered into a license agreement with Gasoline Products Company, Inc., to cover a cracking installation of its own design. The new cracking installation takes the place of the Burton stills heretofore operated. On the Burton still operations, Lion Oil Refining Company has been a licensee of Standard Oil Company (Indiana), for a number of years.

B PRODUCTS for pumping wells
The KEY to LOWER LIFTING COSTS
CORRECTLY DESIGNED • • ECONOMICALLY PRODUCED
REASONABLY PRICED

small well production increased

The Junior Insert Pump will also give longer runs. Inserted type; seating rings located below stuffing box prevent sand from settling.

Illustrated leaflet on request

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Write us relative to your sheet steel requirements. This Company also manufactures U S S STAINLESS and Heat Resisting Steel Sheets and Light Plates for all purposes.

AMERICAN SHEET AND TIN PLATE COMPANY, Pittsburgh, Pa.
SUBSIDIARY of UNITED STATES STEEL CORPORATION

for high pressure oil and gas lines

Two thousand pounds pressure to the square inch can be controlled, and gas can be passed on to the main or the distributing line at reduced pressure to suit requirements, by the use of the proper C-F Regulator. Standard Regulators are designed for pressure up to 600 pounds. For higher pressure, designs are adapted according to specification.

C-F

The Chaplin-Fulton Mfg. Co.

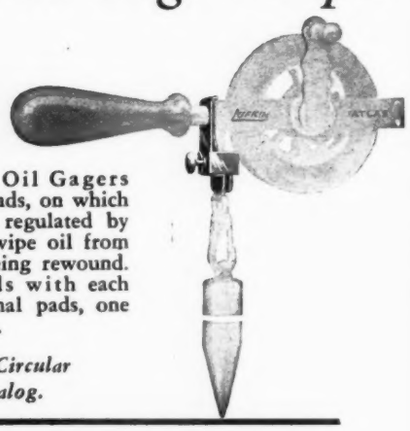
28-40 Penn Ave., Pittsburgh, Pa.

LUFKIN

No. 599 WIPER

will fit ALL

LUFKIN Oil Gagers Tapes



This strong compact wiper is designed to fit *all* LUFKIN Oil Gagers Tapes. Small pads, on which the tension is regulated by thumb screw, wipe oil from line as it is being rewound. Six extra pads with each wiper; additional pads, one dozen in a box.

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SAGINAW, MICH.

New Officers Elected by National Bank of Tulsa

Announcement has been made by the National Bank of Tulsa of the election of E. I. Hanlon as chairman of the board and of A. E. Bradshaw as president of that institution. Mr. Bradshaw succeeds Elmore F. Higgins, who came to Tulsa from New York two years ago.

E. I. HANLON

E. I. Hanlon, new chairman of the board, has been a resident of Tulsa since 1917 and has been active in the oil and gasoline business. He has been identified in financial circles in Tulsa since 1928 and has always been keenly interested in maintaining for Tulsa its prestige as an oil and financial center. Hanlon started his career in the oil business 30 years ago in Sistersville, West Virginia. He is president of Henaghan & Hanlon and chairman of the board of Hanlon-Buchanan, Inc., and has various other connections in the oil and gasoline business.

A. E. Bradshaw, president-elect, has been actively engaged in the banking business in Tulsa since 1901. Formerly a country school teacher in Seymour, Missouri, he came to Tulsa as a clerk in the City National Bank, which was later merged with the First National Bank of Tulsa. Later, with associates, he organized the Bank of Oklahoma, which later purchased the First National Bank, of which he became an officer. He served continuously with that institution until last September, when he resigned as executive vice-president of the First National Bank and Trust Company of Tulsa to accept the presidency of the Oklahoma Natural Gas Company after having been active in the reorganization of that corporation.

A. E. BRADSHAW

Mr. Bradshaw is one of the well and favorably known bankers of the Southwest and brings to the National Bank of Tulsa long experience and a wide acquaintanceship. In commenting on his connection with the National Bank of Tulsa, Mr. Bradshaw said:

"It is a source of deep gratification to me to have been asked to assume the presidency of the National Bank of Tulsa as, in so doing, I become a part of an institution that is outstanding in this section of the country. There are only

two banks, one in the Tenth and one in the Eleventh Federal Reserve Districts that have a larger capital structure than the National Bank of Tulsa, and with this ample capital and with facilities entirely adequate we will be able to care for the needs of business in this section. Our directorate will be active and composed of Tulsa men experienced in all phases of the oil industry and other lines of business. The National Bank of Tulsa is a commercial bank and its services will be available to customers, large or small. The policy of this bank will be constructive yet conservative.

"I am very glad to be identified again with banking in Tulsa in which I have spent practically all my business career and I feel certain that I shall be very happy in my new connection and with my new business associates."

E. I. Hanlon, in assuming the chairmanship of the board, said:

"In accepting the chairmanship of the board of directors of the National Bank of Tulsa I realize my responsibility to the bank, to this community and to the entire Southwest. Tulsa is the recognized center of the oil industry in the Mid-Continent area and is located in the heart of a district with great agricultural and industrial possibilities that are awaiting development. The National Bank of Tulsa has become known as 'The Oil Bank of America' and this reputation will be maintained under the direction of men experienced in all phases of the oil industry.

"The election of Mr. Bradshaw to the presidency of this bank marks a forward step in banking circles in Tulsa and we are all very much gratified to have as our associate an executive of such high standing, wide acquaintance and recognized ability."

Bridgeport Establishes New Distributing Facilities at Houston

The Bridgeport Machine Company, manufacturers and distributors of drilling and production equipment, is rounding out its Gulf Coast distributing facilities with the opening of a new branch store at 2317 Quitman Street, Houston.

This new store, carrying a full line of the company's drilling, fishing and production equipment, as well as tubular products, drilling muds and many other lines distributed for other manufacturers, will serve as general headquarters for Gulf Coast operations of the company, as well as a southern distributing center, from which other Gulf Coast and East Texas branches will be stocked and served.

A complete rental tool service, supplying both rotary and cable fishing and drilling tools and complete drilling outfits, is a feature of the Houston service. And in connection with the regular supply business, a used equipment department, handling used and reconditioned rotaries, drilling and production equipment, and tubular products of all kinds is maintained.

Robert Horton is manager; Hal Craig, field representative; W. L. (Bill) Reynolds, office and warehouse manager, and Roy Bozarth, assistant warehouse man.

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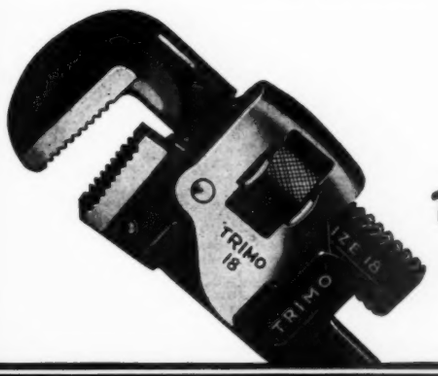

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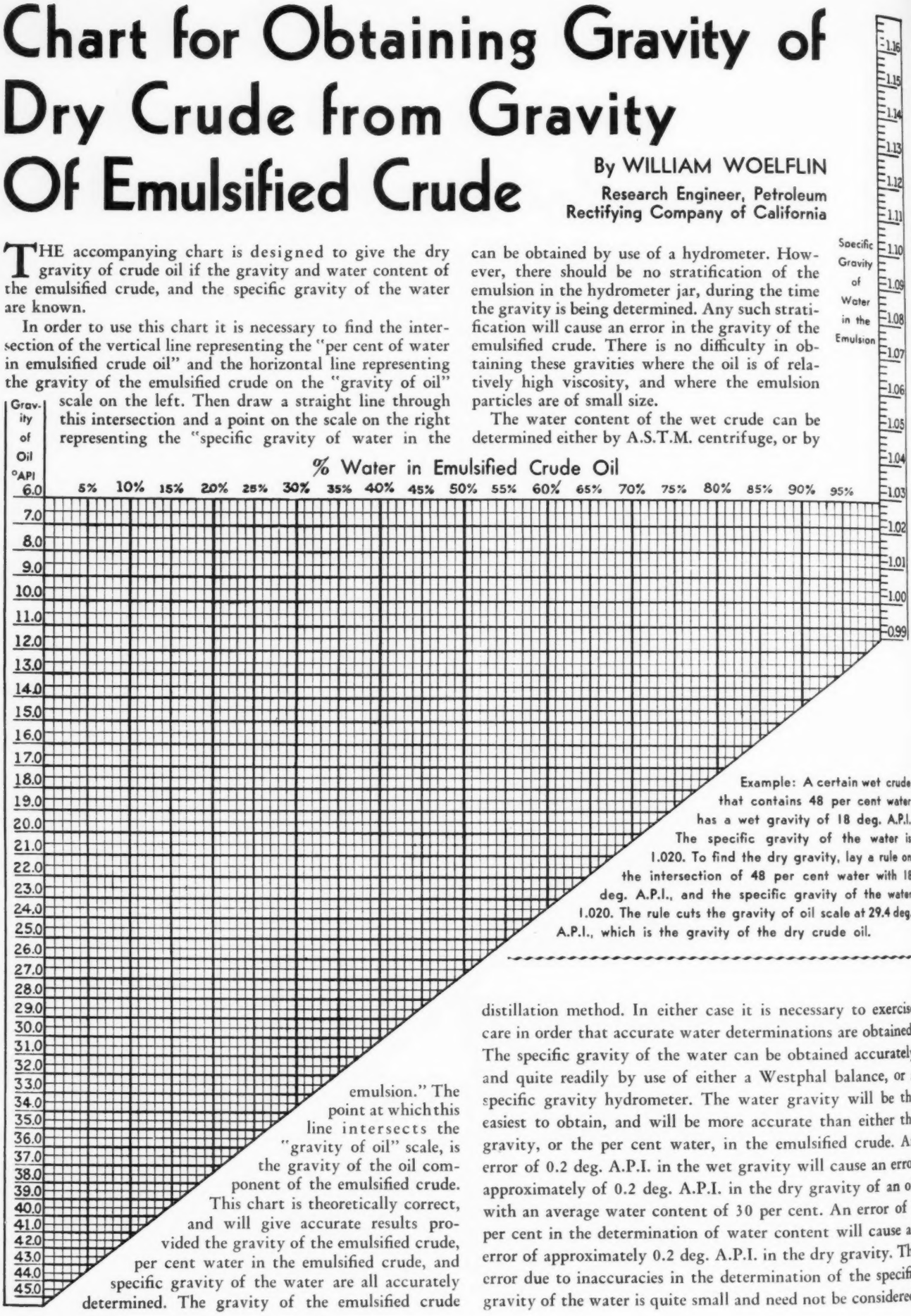
Chart for Obtaining Gravity of Dry Crude from Gravity Of Emulsified Crude

By WILLIAM WOELFLIN
Research Engineer, Petroleum Rectifying Company of California

THE accompanying chart is designed to give the dry gravity of crude oil if the gravity and water content of the emulsified crude, and the specific gravity of the water are known.

In order to use this chart it is necessary to find the intersection of the vertical line representing the "per cent of water in emulsified crude oil" and the horizontal line representing the gravity of the emulsified crude on the "gravity of oil" scale on the left. Then draw a straight line through this intersection and a point on the scale on the right representing the "specific gravity of water in the emulsion." The point at which this line intersects the "gravity of oil" scale, is the gravity of the oil component of the emulsified crude. This chart is theoretically correct, and will give accurate results provided the gravity of the emulsified crude, per cent water in the emulsified crude, and specific gravity of the water are all accurately determined. The gravity of the emulsified crude can be obtained by use of a hydrometer. However, there should be no stratification of the emulsion in the hydrometer jar, during the time the gravity is being determined. Any such stratification will cause an error in the gravity of the emulsified crude. There is no difficulty in obtaining these gravities where the oil is of relatively high viscosity, and where the emulsion particles are of small size.

The water content of the wet crude can be determined either by A.S.T.M. centrifuge, or by distillation method. In either case it is necessary to exercise care in order that accurate water determinations are obtained. The specific gravity of the water can be obtained accurately and quite readily by use of either a Westphal balance, or a specific gravity hydrometer. The water gravity will be the easiest to obtain, and will be more accurate than either the gravity, or the per cent water, in the emulsified crude. An error of 0.2 deg. A.P.I. in the wet gravity will cause an error approximately of 0.2 deg. A.P.I. in the dry gravity of an oil with an average water content of 30 per cent. An error of 1 per cent in the determination of water content will cause an error of approximately 0.2 deg. A.P.I. in the dry gravity. The error due to inaccuracies in the determination of the specific gravity of the water is quite small and need not be considered.



Example: A certain wet crude that contains 48 per cent water has a wet gravity of 18 deg. A.P.I. The specific gravity of the water is 1.020. To find the dry gravity, lay a rule on the intersection of 48 per cent water with 18 deg. A.P.I., and the specific gravity of the water 1.020. The rule cuts the gravity of oil scale at 29.4 deg. A.P.I., which is the gravity of the dry crude oil.

The errors due to inaccuracies in the gravity and water content of the emulsified crude, may be either additive or compensating. That is, if the gravity is read 0.2 deg. A.P.I. too high, and the water content is read 1 per cent too low, the errors will balance out and the final result will be correct. If the gravity is read 0.2 deg. A.P.I. too low, and the water content is read 1 per cent too high, the errors will be additive. Even in the latter case the result should be within 0.4 deg. A.P.I., which should be the maximum error when using the chart. However, if the gravity and water content are determined more accurately than the limits shown above, then the errors in using the chart will be reduced proportionately.

Since there are no tables that can be used to change the observed gravity of an emulsified crude oil to the gravity at 60 deg. fahr., it is necessary to determine the gravity of the emulsified crude and the gravity of the water at the same temperature. The chart will then give the gravity of the dry crude, at the temperature at which the gravity of the emulsified crude was determined. The National Standard Petroleum Oil Tables can then be used to correct this gravity of the dry crude to 60 deg. fahrenheit.

This chart was originally designed for obtaining the gravity of a dry crude oil from the gravity of emulsified crude oil. However, the chart is not limited to this particular use. There are four variables in the chart and if any three are known the fourth can be obtained. The four variables are:

1. Gravity of emulsified crude oil.
2. Gravity of dry crude oil.
3. Water content of emulsified crude oil.
4. Specific gravity of water in the emulsion.

This chart will probably be used in most cases to obtain the gravity of the dry crude oil when the other factors are known. It may also be just as useful for checking water contents of emulsified crude oils, when the gravities of the emulsified crude oil, dry crude oil, and water are known.

A limited number of the charts have been reproduced on cards suitable for office and desk use.

Youngstown to Enlarge Briar Hill Plant

The Youngstown Sheet & Tube Co. plans to expand its present electric weld mill, at its Briar Hill plant in Youngstown, Ohio, to include production of smaller sizes of electric-welded pipe, it was announced today by Frank Purnell, president of the company.

The mill now manufactures electric-weld pipe in sizes from 18 to 26 inches. The new extension of the mill will permit manufacture of pipe from 16 in. down to eight in., and intermediate sizes. This will give the company a range in size of electric-weld pipe from eight in. to 26 inches. The cost of the extension will be approximately $500,000.

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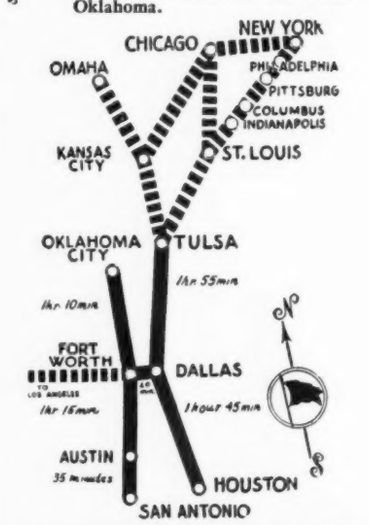


Bowen Air Lines

Benjamin F. Harris Is New President of National Tube Company

Benjamin F. Harris, president of the Oil Well Supply Company, has been elected president of the National Tube Company. Both companies are subsidiaries of the United States Steel Corporation, and for the present at least Mr. Harris will continue as president of Oil Well.

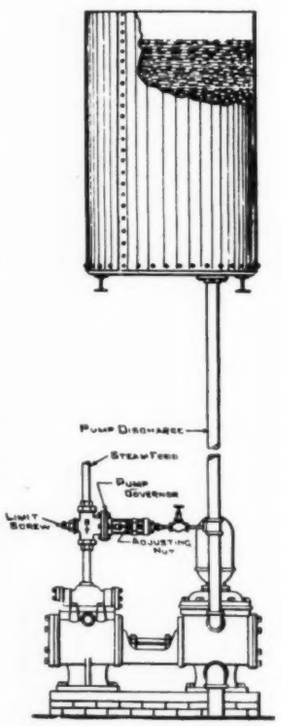
Mr. Harris' first connection with the steel industry was with the American Sheet & Tin Plate Company in 1903. Later, he became vice-president of the Wilson-Snyder Company, from which position he was transferred to the presidency of the Oil Well Supply Company. He succeeds F. W. Waterman, who retired, effective January 1st.

Wear Is New President of Harrisburg Pipe and Pipe Bending Company

Wilbert Wear, treasurer, Harrisburg Pipe and Pipe Bending Co., Harrisburg, Pa., has been elected president to succeed the late Charles B. Houck. He will also continue as treasurer, to which position he was elected in 1929. N. W. Cassel, secretary, has been elected vice-president, continuing his duties as secretary. H. B. Liggett, heretofore general plant superintendent, has been appointed general manager.

Water Level Without Floats

By W. F. SCHAPHORST
Mechanical Engineer



Regulating devices are now being made so sensitive that floats, float valves, indicators, etc., may be dispensed with in maintaining water level in a tank. The accompanying sketch shows how it is done. A pump governor controlled by the water pressure in the pump discharge pipe opens and closes the steam line to the steam end of the pump as the water in the tank rises and falls. After the pump governor is once adjusted to close the steam line at a given pressure it automatically maintains the desired water level in the tank.